



AGRICULTURAL RESEARCH INSTITUTE  
PUSA







# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOLUME XXVIII, 1936

CONSISTING OF I-IV—633 PAGES,  
INCLUDING FIGURES; ALSO 1 PORTRAIT



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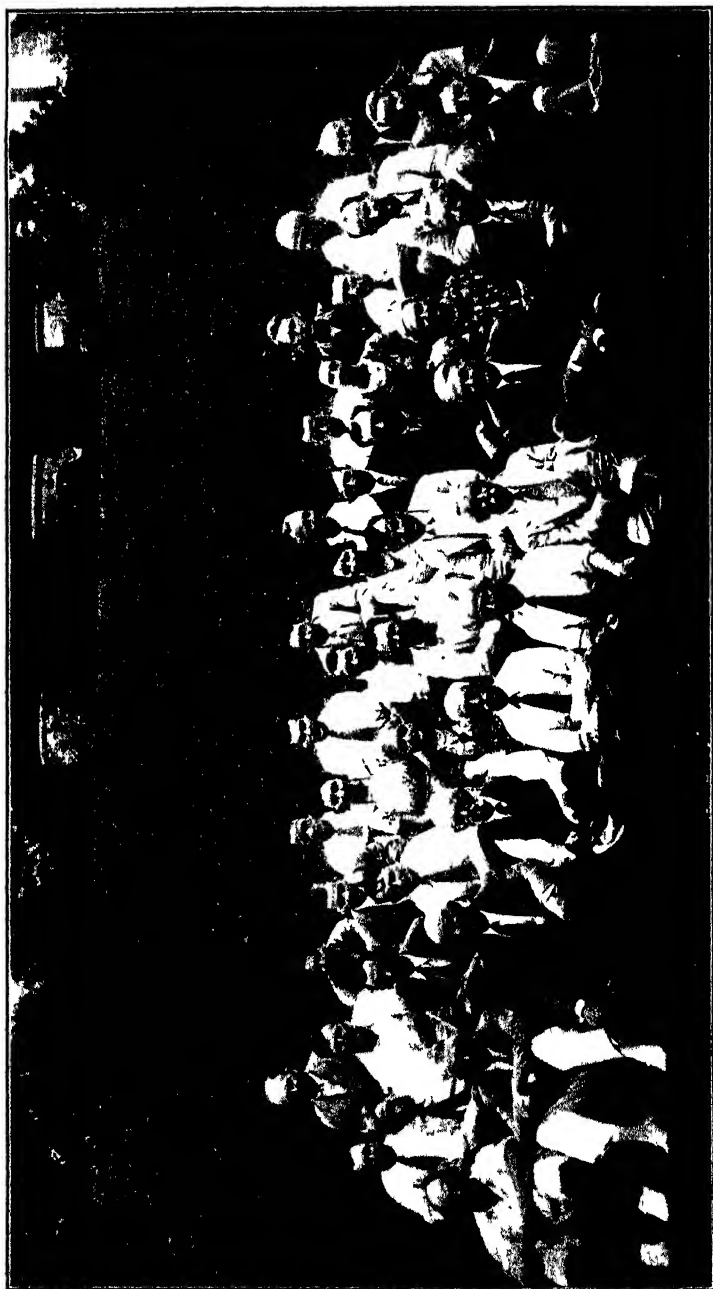
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SUMMER FORAY—1935

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVIII

JAN.-FEB., 1936

No. 1

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXII. DASYSYPHA<sup>1</sup>

FRED J. SEAVER

(WITH 1 FIGURE)

The writer has recently received from Dr. H. S. Jackson a species of the above genus collected by Dr. Roy F. Cain which is of more than usual interest. The name *Dasyscypha* is here used in a broad sense, including both *Lachnum* and *Dasyscypha*, which, in the opinion of the writer, cannot be satisfactorily separated on the character of the paraphyses as is sometimes done.

The specimen referred to has been determined by the writer as *Dasyscypha crucifera* (Phill.) Sacc. The only other specimen of this species seen is in the herbarium of The New York Botanical Garden (Phillips, *Elvellacei Britannici 162*), together with illustrations of Phillips' material made by George Massee.

When the Canadian material was first examined it was thought to be *Dasyscypha nivea* (Hedw.) Sacc., which, in the opinion of the writer, is synonymous with *Dasyscypha virginea* (Batsch) Fuckel. The presence of minute granules on the outside of the apothecia, however, was puzzling. It was finally decided that it was *Dasyscypha crucifera* (Phill.) Sacc. In checking the matter the writer was interested in the differences of opinion, between M. C.

<sup>1</sup> This paper is preliminary to a monograph of North American Cup-fungi (inoperculates), a companion volume to North American Cup-fungi (operculates), which was published by the author and issued in December, 1928.

[MYCOLOGIA for November-December (27: 553-660) was issued  
December 1, 1935]



Cooke and William Phillips, on the validity of this character. It is thought worth while to quote these opinions. The writer is inclined to accept Phillips' interpretation, in view of recent observations.

#### COOKE'S CRITICISM

From The Gardeners' Chronicle II. 10: 442. 1878. "*Peziza crucifera*, Phil.—I quite agree with Mr. Phillips that the crystals surmounting the hairs in this species is an interesting phenomenon, but nothing more. If he has satisfied himself that they are inorganic crystals, then they are not permanent characters, and unless other and distinctive characters can be found the species is a false one. The name *crucifera* is unfortunate, because the crosses on the hairs are no essential parts of the plant. Manifestly, if crystals of oxalate of lime, or crystals of a similar character, were found upon the hymenium of *Peziza aurantia*, Mr. Phillips would not regard it as a distinct species on that account. It is so seldom that my friend Phillips differs from me on essential points, and we are most constantly in correspondence, that I am disposed to regret that we did not discuss this subject previous to the publication of the name. Some time since, when we had this *Peziza* under review, the inorganic character of the crosses had not been mooted; the determination of this point now places the whole question upon a different basis. Probably, as I suggested twelve months since, the crystals which surmount the hairs of *Peziza echinulata*, Awd., are also inorganic, and, if so, must have no place in a specific diagnosis. I was led to the conclusion that this was the case in *P. echinulata*, because, on examining a specimen mounted in glycerine, after twelve months' rest, I could find no trace of the terminal stellate appendages. On remarking upon this circumstance at the time, it was objected that glycerine would in time render these delicate crests so transparent that they would not be recognisable. I have also a memorandum to the effect that similar crystals had been detected on the hairs of fresh specimens of two other foliicolous species on which they are not usually found. I have used the term 'crystals' in all these instances because they most resemble crystals in form. Moreover, I feel strongly impressed with the suspicion of their being 'crystals' in fact, in all these cases, and that they must be left

entirely out of account as specific characters. If there are no features but the stellate apices of the hairs to distinguish *P. crucifera* from *P. virginea*, I must in candour decline to accept *Peziza crucifera* as a distinct species." M. C. Cooke.

#### PHILLIPS' ANSWER

From The Gardeners' Chronicle II. 10: 473. 1878. "*Peziza crucifera* (Phillips).—Dr. Cooke considers (p. 442 ante) the name I have given to this little species 'unfortunate, because the crosses on the hairs are no essential part of the plant.' I would say in reply to this objection that the name expresses a character which, as far as our knowledge goes, is invariably present, and is directly traceable to a function of the plant. Even if the crosses resulted from some source foreign to the plant, still being always found in the curious position they occupy, the name would be as allowable as many others given and accepted by mycologists, and even by my friend Dr. Cooke himself. It is highly probable, if not certain, that these crosses, or more properly crystals, result from a fluid excreted from the terminal cell of each hair, which, collecting in a globule on the exterior, deposits a single crystal of oxalate of lime. At the recent meeting of mycologists at Hereford I offered this as a reasonable explanation of the phenomenon, and further said that I had noticed transparent granular masses of matter occupying a similar position in the following species: *Peziza solfatera*, Cooke and Ellis; *P. epixantha*, Cooke; *P. papillaris*, Sow.; *P. clandestina*, Bull; *P. Schweinizii*, Awd.; *P. palearum*, Des.; *P. latebricola* (Rehm); *P. rosea* (Rehm); *P. brunneola*, Desm.; *P. echinulata*, Awd.; *P. patula*, Pers.; *P. barbata*, Kunz; *P. Spiraea*[e], Schw.; *P. pellita*, Pers.; *P. marginata*, Cooke; *P. scabrovillosa*, Phillips; and a species unnamed in Mr. Berkeley's herbarium from the Nilgherries. These masses of granular matter have been for some time known to exist on the points of the hairs of several species, but no satisfactory explanation has ever been offered of their nature. The definite crystals on *Peziza crucifera* throw a new light on them, and point clearly to the fact that they also are amorphous masses of probably carbonate or oxalate of lime. The most formidable objection offered by Dr. Cooke is not that to the appropriateness of the name, which

I think is sufficiently answered above, and may therefore be dismissed, but to the validity of the species, unless some other characters than this one can be pointed to as distinguishing it from *Peziza virginea*. This is undoubtedly a very serious objection, unless it can be fairly met. Having drawn up my diagnosis previous to being made aware by Mr. Berkeley of the nature of the crystals, I may have relied too much on their presence and omitted other essential characters. That it is not the same species as *P. virginea*, however, will be seen at once by comparing Dr. Cooke's own figure of that species in Grevillea (vol. iv., tab. 51, fig. 272) with my figure of *P. crucifera* in the Gardeners' Chronicle, p. 397. The hairs of *P. virginea* are there represented as non-septate, cylindrical hairs, whereas in *P. crucifera* they are distinctly septate and enlarged at the summits. *P. crucifera* has not hitherto been detected on any other plant beside *Myrica Gale*, and I presume is peculiar to it. To my own mind, and I venture to think to the mind of most mycologists, such differences, coupled with the invariable phenomenon of the crystal surmounted hairs, will establish the validity of the species." William Phillips.

#### BERKELEY'S COMMENTS

Apparently in letter to Phillips: "I have with great pleasure examined your *Peziza*. I find that the crosses fall off, and I suspect that they are crystals; but if so the matter is not less curious. They are something like crystals of carbonate of lime, and nearly resemble some forms of crystals of oxalate of lime. The subject is worthy of further consideration. I have little doubt they are crystals."

"It is well known that oxalate of lime and binoxalate of potash occur not unfrequently in fungi, but we have never seen crystals of the former in such a curious position as in a minute white *Peziza*, lately sent by Mr. W. Phillips, one of the most indefatigable and accurate observers of minute fungi. Every hair with which the cup is clothed is terminated by a single crystal of a most beautiful and well-defined form, giving the whole under the microscope a most interesting appearance. The matter is at first puzzling, but the moment the crystals drop off their true nature is at once abundantly clear. M. J. B."

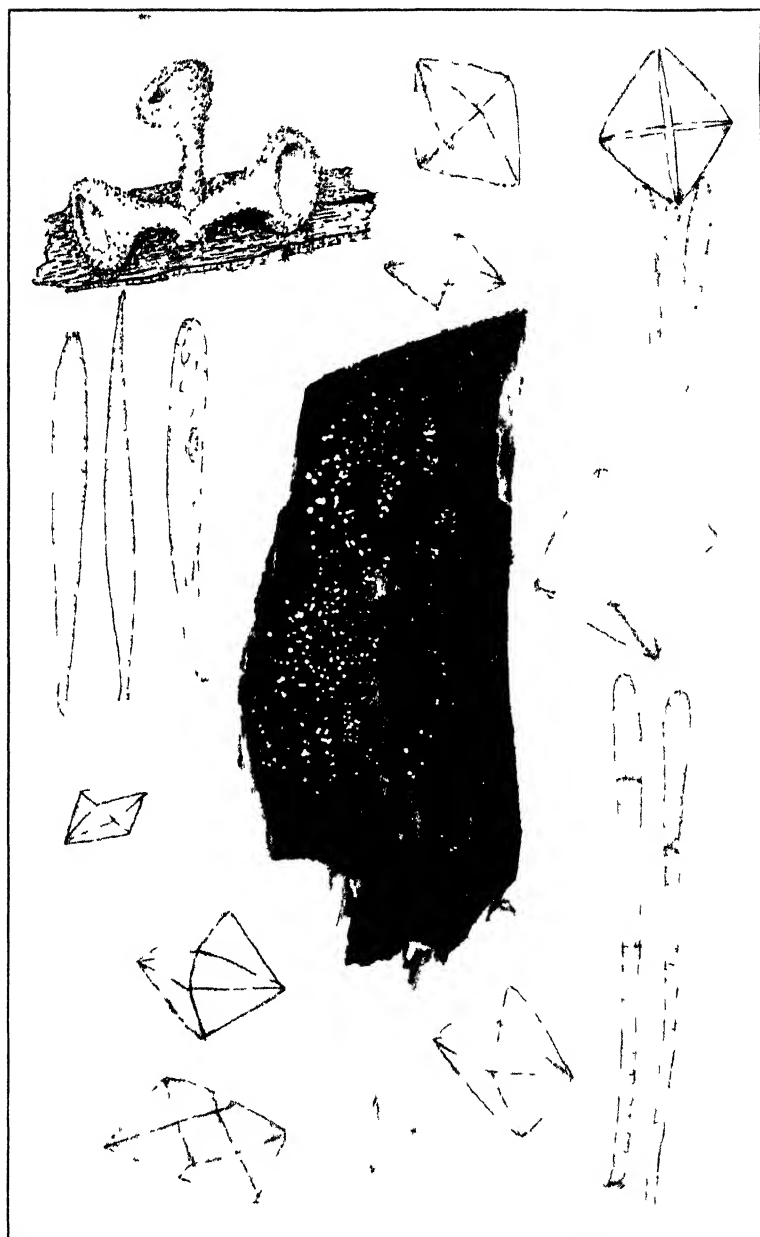


FIG. 1. *Davyscypha crucifera*.

Phillips writes: "Though perfectly satisfied that this view was the correct one, I obtained the assistance of my friend, Mr. T. P. Blunt, a very able analytical chemist of this town (Shrewsbury), who satisfied himself by such chemical means as were possible with such minute objects that they consisted of oxalate of lime."

#### DIAGNOSIS

DASYSCYPHA CRUCIFERA (Phill.) Sacc. Syll. Fung. **8**: 44. 1889.

*Peziza crucifera* Phill. Gard. Chron. **II**. **10**: 397. 1878.

*Lachnella crucifera* Phill. Brit. Discom. 250. 1893.

Apothecia stipitate, reaching a diameter of .5–1 mm., shallow cup-shaped with hymenium pale yellowish, externally clothed with hairs intermixed with crystals of calcium oxalate giving them a granular appearance; stem reaching a length of .5–1 mm. and also clothed with hairs; hairs clavate septate, reaching a length of  $80\ \mu$  and a diameter of  $4\ \mu$ ; asci clavate, reaching a length of  $40\ \mu$  and a diameter of  $5\text{--}6\ \mu$ , 8-spored; spores minute about  $2 \times 5\text{--}6\ \mu$ ; paraphyses lanceolate.

On rotten wood.

TYPE LOCALITY: Europe.

DISTRIBUTION: Canada; also in Europe.

ILLUSTRATIONS: Gard. Chron. **II**. **10**: fig. 11.

#### EXPLANATION OF FIGURE 1

Center, photograph of apothecia, about natural size; upper left, drawing of three apothecia much enlarged; left asci and paraphysis; right and bottom, hairs and crystals from outside of apothecia.

NEW YORK BOTANICAL GARDEN

# INSECTS AS POSSIBLE DISTRIBUTORS OF PHYMATOTRICHUM ROOT ROT <sup>1, 2</sup>

J. J. TAUBENHAUS AND L. DEAN CHRISTENSON

Studies were undertaken in 1933 to determine whether certain insects found in cotton fields are capable of spreading cotton root rot caused by the fungus *Phymatotrichum omnivorum*. These studies consisted of experiments to determine (1) if the alimentary fluids of soil insects have a lethal effect on the vegetative strands and the sclerotia of the fungus which would prevent dissemination by means of feces, and (2) the effect of the alimentary fluids of other insects, particularly leaf-feeding insects, on the viability of the spores of this fungus. Observations were also made to ascertain whether the destruction of fungus strands in the soil of cotton fields by the feeding of insects would allow recovery of areas infected with root rot.

## EFFECTS OF SOIL INSECTS ON STRANDS AND SCLEROTIA OF PHYMATOTRICHUM OMNIVORUM

Three species of soil-inhabiting insects, white grubs (*Phyllophaga* sp.) and adults of *Blapstinus fuscus* Csy. and *Harpalus* sp., were caged and fed on freshly infected cotton roots covered with copious strand growth of *P. omnivorum*. When they had consumed sufficient quantities of this material, 16 of these insects were killed, surface-sterilized, and cultured on potato-dextrose agar in Petri dishes. The other insects were left undisturbed and their fecal pellets collected and cultured. A total of 2,169 fecal pellets were thus obtained, some of which were cultured without surface sterilization while others were surface-sterilized and cultured on potato-dextrose agar in Petri dishes. In not a single instance was *Phymatotrichum* growth obtained either from the fecal pellets or from the entire insects.

<sup>1</sup> Published with the approval of the Director as Contribution No. 290, Technical Series, Texas Agricultural Experiment Station.

<sup>2</sup> Bureau of Entomology, U. S. Dept. of Agriculture, Ms. No. 2694.

In making excavations in the field to find sclerotia of *P. omnivorum*, some are occasionally found in a damaged condition, as though fed upon by soil insects or other soil animals. However, none of the insects used in these experiments could be induced to feed on fresh, mature field sclerotia placed in screened cages in the laboratory.

#### EFFECT OF INSECTS ON SPORES OF PHYMATOTRICHUM OMNIVORUM

Cotton leaves from normal cotton plants were dusted with a heavy coating of spores of *Phymatotrichum omnivorum* and then fed to larvae of *Alabama argillacea* Hbn., *Heliothis obsoleta* Fab., and *Laphygma frugiperda* S. & A., and to adult grasshoppers in screened cages in the laboratory. A total of 4,759 fecal pellets were obtained from these insects; half of these were surface-sterilized and the other half were not sterilized, and both were cultured on potato-dextrose agar in Petri dishes. A number of grasshoppers and *A. argillacea* larvae were killed, surface-sterilized, and cultured on nutrient agar in Petri dishes. In not a single instance was *Phymatotrichum* growth obtained from either the fecal pellets or the entire insects.

In other experiments a heavy suspension of *Phymatotrichum* spores in a 1 per cent sugar solution in small dishes was placed in screened cages containing the following ants: *Pogonomyrmex barbatus* F. Smith var. *molefaciens* Buckley; *Dorymyrmex pyramicus* Roger var. *flavus* Perg.; and a species of *Prenolepis*. The ants partook of the sugar solution with apparent relish and imbibed large quantities of the spores of *P. omnivorum*. After 24 hours' feeding, they were killed, surface-sterilized, and cultured in potato-dextrose agar in Petri dishes. In not a single instance was *Phymatotrichum* growth obtained from the many cultures thus made.

#### FIELD OBSERVATIONS ON EFFECTS OF INSECTS FEEDING ON *P. OMNIVORUM*

Certain insects have been observed to feed upon the various stages of the fungus of root rot in nature, reducing the infective element in the soil which would reinfect plants during subsequent years. After considerable observation in the field it has been

concluded by the writers that this function is a minor one. It is doubted that soil animals would ever act in this capacity to the extent of clearing up root-rot areas. Such a conclusion is based on observations regarding the habits and abundance of organisms in the soil, as compared with the habits and abundance of the fungus in the same area. Where root-rot areas recover, soil organisms are perhaps a contributing factor but never a causative one.

#### SUMMARY

A number of insects were placed in screened cages in the laboratory, where they were fed on strands and on cotton roots freshly infected by *Phymatotrichum* root rot. The fecal pellets and some of the insects themselves were cultured on potato-dextrose agar in Petri dishes, but *Phymatotrichum* growth was not obtained from any of these cultures.

A number of insects were fed on cotton leaves which were dusted with a heavy coating of the spores of *P. omnivorum*, while others were fed on a sweetened solution containing a heavy suspension of *Phymatotrichum* spores. No growth of *P. omnivorum* was obtained from any of the cultures made of the fecal pellets or the entire insects thus fed. None of the insects used in these experiments could be induced to feed on the sclerotia of the fungus. From these preliminary tests it appears that insects are probably not involved in the spread of *Phymatotrichum* root rot.



## FUNGI FROM LABORATORY REAGENTS

LEWIS B. LOCKWOOD<sup>1</sup>

Occasional reference to the occurrence of molds in the reagents of a chemical laboratory may be found in chemical and mycological literature. In order to prevent the spoilage of some organic reagents, it is common practice to cover them with toluene, or to poison them with some substance which will not influence the chemical behavior of the material or interfere with the reactions of the reagent. Thom (5) reported the occurrence of *Penicillium lilacinum* Thom from nickel-electrotyping baths. Trabut (6) provisionally offered the name *P. cupricum* for an organism which differed from *P. glaucum* Link only in that it produced rose-colored conidia. Cultures were obtained from a solution (originally 9.5 per cent of  $\text{CuSO}_4$ ) which had been used for seed treatment of wheat imported into France from Africa. DeSeynes (4) made a further study of the growth of *P. cupricum* Trabut on  $\text{CuSO}_4$  solutions, and demonstrated that the rose color of the conidia was a reaction of the fungus to the  $\text{CuSO}_4$ . *P. cupricum* Trabut was declared synonymous with *P. glaucum* Link. Gueguen (3) reported that *P. glaucum* grew on solutions of copper sulfate in the concentration of 1 part  $\text{CuSO}_4$  to 200 parts water. Westling (8) described *Byssoschlamys nivea*, isolated from botanical specimens which were preserved in alcohol. *B. nivea* tolerated a concentration of 90 per cent of alcohol, or 5 to 10 per cent tannin. Gronchi (1, 2) described *Anematidium oxiphilum* Gronchi, which grew in the presence of N/2 hydrochloric acid and N/2 sulfuric acid. Wehmer (7) obtained a *Citromyces* sp. (*Penicillium*) from a solution which contained 0.5 per cent of sulfuric acid which had been used to hydrolyze cotton.

During the last three years, a number of rather striking examples of the tolerance of fungi to standard chemical laboratory reagents have come under observation in this laboratory. Fungi

<sup>1</sup> 252d Contribution from the Color and Farm Waste Division, Bureau of Chemistry and Soils, U. S. Department of Agriculture, Washington, D. C.

were found growing in reagents used for sugar determinations. These reagents consisted of a solution containing 2.48 per cent  $\text{Na}_2\text{S}_2\text{O}_3$  and 0.2 per cent  $\text{NaHCO}_3$ , and a modified Benedict's solution which contained 2.5 per cent  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , 5 per cent  $\text{Na}_2\text{CO}_3$ , and 9 per cent  $\text{NaC}_6\text{H}_5\text{O}_7 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ . A fungus isolated from the modified Benedict's solution grew slowly, and formed a thin white pellicle of surface hyphae on cornmeal agar, but did not sporulate. Another fungus (no. 536) isolated from a similar solution proved to be a strain of *Aspergillus Sydowi* (Bainier and Sartory) Thom and Church, which was characterized by abundant sporulation upon a 2 per cent agar medium containing 15 per cent of glucose and 0.5 per cent of peptone, by the conidiophores arising from subsurface hyphae, and occasionally with branching of the conidiophores, each branch being terminated by a vesicle indistinguishable from those borne on unbranched stalks.

*Fusarium orthoceras* App. & Wr. (no. 537) was isolated from a 0.5 per cent solution of potassium acetate. This culture grew over the surface of the peptone glucose agar medium, and formed a deep-purple coloration, with abundant sporulation.

*Penicillium lilacinum* Thom was isolated from a 9 per cent solution of sodium acetate. *Endomyces* sp. was isolated from a 10 per cent  $\text{CaCl}_2$  solution. This culture piled up a black yeast-like growth on peptone-glucose agar. True filaments with lateral buds somewhat similar to those of *Sporotrichum* were abundant in cultures, and single naked asci occurred rarely in old cultures.

Various *Aspergilli* of the glaucus and flavus-oryzae groups have been obtained from 20 per cent  $\text{NH}_4\text{NO}_3$  and 10 per cent  $\text{NaCl}$  solutions. A vigorous strain of *A. fumigatus* Fres. with large heads was isolated from a 30 per cent  $\text{KNO}_3$  solution. The conidia of this culture were at first pale ochraceous, passing through various shades of green to walnut-brown. A culture of the *A. niger* group with morphological characteristics lying between *A. niger* van Tieghem and *A. Phoenicis* (Corda) Thom, and a culture of *A. Tamaritii* Kita were isolated from a saturated aqueous solution of dimethyl-dihydro-resorcinol, and a sterile fungus was obtained from a saturated solution of resorcinol. A strain of *Penicillium purpurogenum* Stoll was isolated from a

0.5 per cent solution of  $H_3PO_4$ . This culture produced gluconic acid from glucose, and in the presence of peptone, produced a very intense purple color, which became yellow in alkaline solution. Fungi have also been found in this laboratory in saturated solutions of indigo and 20 per cent solutions of gold chloride.

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## NOTES ON BOLETES. IV

WALTER H. SNELL

The previous papers on the boletes have been concerned for the most part, with elucidating some of the obscurities or misunderstandings concerning the more common species. Henceforth, such discussions are bound more and more to concern the more rare and more obscure forms, and also the establishment of new species as they come to light.

### SPECIES PREVIOUSLY DISCUSSED

#### *Boletus Curtisii*

In Notes III (pp. 356–358),<sup>1</sup> it was concluded that *B. carolinensis* Beardslee was the same as *B. Curtisii* Berk. because in the specimens of the latter examined there was no reticulation of the stipe as given in one of Berkeley's two descriptions.

In another examination of the Peck material at Albany during the past summer, I was again unable to distinguish any reticulation of stipes of plants labelled *B. Curtisii*. On the other hand, in Peck's type specimens of *B. fistulosus*, which are without doubt the same as *B. Curtisii*, as pointed out by Murrill, I did see a small amount of reticulation. This marking was found in small patches at the very apex of the stipe of one of the two plants. Thus the confusion in Berkeley's descriptions is explained. It appears then that the stipe of this species may be slightly reticulate in places, but from the material available to me, there can be no reason for calling the stipe "reticulate" and the conclusions of last year's notes still hold.

#### *Boletus leucophaeus*

This species was distinguished for the first time in this country in 1933 (see Notes III, loc. cit.). From collecting experience in 1934, this species appears to be not at all uncommon. I found it several times in several places in New York. It is quite likely

<sup>1</sup> Mycologia 26: 348–359. 1934.

that if old collections of specimens labelled "*B. scaber*" are examined carefully, it will be found that a small proportion of them are really *B. leucophaeus*. This species is easily identified by its dark brown to almost black, tomentose pileus and the spores larger and darker colored than those of *B. scaber*.

### *Boletus placidus*

It is likewise true that some of the collections of *B. granulatus* will turn out upon examination to be *B. placidus*. When *B. granulatus* has been rained upon, especially during development of the sporophore, it will become much blanced if not quite white or sometimes becoming yellowish-white. *B. placidus* will likewise often have a greenish-yellow margin, although I have usually found it without yellow and with the white more ivory than pure white. The glandular dotting of the stipe of this species is coarser, with the dots usually confluent and connecting to form a coarse network. When once this feature has been noted, it will be remembered and will make tentative identifications simple. The European illustrations show this character very well. Further, there is a difference in the spores. Those of *B. placidus* are over 8  $\mu$  long, while those of *B. granulatus* are less than 8  $\mu$  long. In the American specimens I have found the spores of the latter have been only 6-7  $\mu$  long, but in some Canadian collections they have been 7-8  $\mu$ .

### SPECIES NOT PREVIOUSLY DISCUSSED

#### *Boletus impolitus*

As far as I am aware, this common European species has been reported only by Harkness and Moore from California and by McIlvaine from Pennsylvania, although the latter writer implied that it had been found and eaten by many individuals whom he knew. Atkinson reported *B. obsonium* Paulet as not uncommon in one of his collecting places in North Carolina, which species is considered quite generally by French mycologists to be the same as *B. impolitus*, or a vinaceous- or pinkish-tinged form of it. Peck did not see it and Murrill did not recognize it as an American species.

During the irritatingly dry summer of 1934 in the Adirondacks,

when collecting of fleshy forms was very unsatisfactory, I ran across this interesting species in one of my favorite collecting grounds near Riverside, N. Y. I found it first in a very young stage in which it was not identifiable but patently unusual. I ultimately made four more trips to the locality, driving 500 miles in all, meanwhile protecting it with a cage to keep the squirrels from destroying it and watering it to prevent it from mummifying because of the drought, but in the end I had two perfectly developed sporophores which were manifestly *B. impolitus*.

These sporophores were found under a hemlock tree with hardwoods near by. In Europe it is described as associated with hardwoods by some writers and by others as only under oaks. In my locality, there were no oaks within a considerable distance. The only aberrant features manifested by my plants were as follows: changing of the flesh in places and of the tubes slightly to greenish when cut or bruised (no change in European plants); no odor of phenol or drugs as sometimes given for the European plants; one micron difference in the length of spores. Otherwise the agreement is as nearly perfect as it could be.

### *Boletinus paluster*

This is apparently a rare species. At least I have searched for years for a red *Boletinus* in all the swampy regions I have passed in New England, New York and Pennsylvania without finding it. I have made special trips several times a summer to one tamarack swamp near Galway, N. Y., where Dr. E. A. Burt once found it, but to no avail. Then late in the summer, following a heavy rain, I found it in great abundance along a path that I have travelled no less than one hundred times in the past six years without coming across it. Further, judging by the descriptions available, it apparently has not been encountered before by many other collectors, for the descriptions are not only entirely inadequate, but also, if my series of collections of a couple hundred sporophores in all stages of development over a period of two weeks is any criterion, they are inaccurate in many details.

I had been looking for a "bright red" *Boletinus* (Peck's reproduction is almost a cerise). The color of my specimens was nothing if not a purple—a true purple that was very red or even

pinkish but certainly not any of the so-called reds. The young sporophores had a prominent veil which was at first fibrous-membranous and deep red, then arachnoid and pinkish, grayish or whitish. This veil was for a while appendiculate on the margin of the incurved pileus, but disappeared as the margin expanded. This veil also left at least a red line at the zone on the stipe where it broke away and sometimes was to be seen as deep-red punctations at this zone. There was, however, nothing that could be called an annulus.

The tube layer was decidedly decurrent, not slightly so, and it did not turn bluish-green no matter how much I bruised it. The shallow tubes, or almost merulioid pits, were definitely boletinoid, of course, but also in many specimens, the tube layer was so prominently veined as to be almost lamellate instead of poroid. It would seem as if in this species there is further evidence of the relationship of the boletes and the agarics, as has been suggested by many writers previously, through *Phylloporus* and *Paxillus*. Here in one collection was seen a complete gradation from the almost lamellate and intervenose to the poroid and veinless, although still with the pores in radiating rows instead of with free arrangement.

Further, the available descriptions speak of the stipe as yellow strongly tinged with red. The stipes of my specimens were yellow at the apex and base but in between were decidedly purplish red with no yellow, the red ending abruptly at the zone of attachment of the veil. The spores have been given as dirty-greenish-yellow when fresh, then pinkish-brown. I found them to be deep reddish purple, with no sign of green or yellow.

The odor and taste have not been recorded, so far as I know. Both are farinaceous, although after a little chewing the taste becomes slightly but persistently acid.

The foregoing characters will help to make more complete the technical description of this striking little *Boletinus*, but they are not necessary for a certain field identification. A small, red-purple, more or less turbinate or almost cantharelloid bolete found in northern swamps or moist places growing tamarack or balsam can be this species only. The common and somewhat similarly colored and marked *Boletinus pictus* is larger and more expanded, and is more likely to be met with near *Pinus Strobus*.

*Boletus Gertrudiae*

Shortly after examining *B. Curtisii* for reticulate stipes, I came across another error in this same respect in connection with *B. Gertrudiae* Peck. In the original descriptions, English and Latin, Peck made no mention of the topography of the surface of the stipe. In the type specimens at Albany, the stipes are today plainly reticulated for a distance of one to three centimeters at the apex. In Miss Wells' water color drawing, which accompanies the collection, no reticulation is represented, but the drawing is only a sketch without details, giving only general color, form and presumably size.

On the basis of this character, I would be inclined to place this species in the tribe Calopodes rather than in the Subpruinosi, where it would be placed if this reticulation were not present. The species of this latter tribe do not have reticulate stipes, altho *B. miniato-olivaceus* and *B. bicolor* may be reticulate with the descending walls of the tubes for a few millimeters.

*Boletus indecisis*

There has been much confusion concerning the taxonomic differentiation of *B. felleus*, *B. alutarius* and *B. indecisis*. *B. felleus* is the rosy-tubed and rosy-spored bolete, with bitter taste, common both here and in Europe. *B. alutarius* was distinguished by Fries on the basis of its mild taste and stipe more scrupose than reticulate. Peck found an American plant likewise with mild taste and with spores darker in color than those of *B. felleus* and with stipe reticulate like that of *B. felleus* rather than scrupose like that of *B. alutarius*. He named it well as *B. indecisis*, for its status has been more or less undecided ever since.

Several mycologists have thought that *B. indecisis* of this continent and *B. alutarius* of Europe are the same plant. Murrill<sup>2</sup> said that "specimens referred to *B. alutarius* Fries by American collectors probably belong in this category" (*B. indecisis*). In fact, the difference between a scrupose stipe and a reticulate one seems to be difficult of determination. Many French mycologists, however, believe that there is in reality no *B. alutarius*. For example, in a recent letter, Gilbert says the following:—" . . . *B.*

<sup>2</sup> The Boletaceae of North America. Mycologia 1: 4-18. 1909.



*alutarius* is in my opinion identical with *B. felleus* . . . The alveolae of the reticulations of *B. felleus* are often very deep. Fries says the taste is mild but one finds also the true *B. piperatus* mild. . . . It appears to me certain that there exists in France and also in Europe, only one bolete with rosaceous spores, *B. felleus*. Consequently, I consider *B. alutarius* an imaginary species."

If *B. alutarius* is the same as *B. felleus* in Europe, I am convinced that *B. indecicus* is a valid species. Not only does it have a mild taste and spores more brownish- or ochraceous-incarnate in mass than rosy-incarnate, as are those of *B. felleus*, but the sporophores are smaller, the flesh more firm, and the spores are distinguishable microscopically. The spores of *B. felleus* are elliptical to fusiform-elliptic but more inclined to be fusiform in shape, and measure  $9-15 \times 3-4 \mu$ , with most of them  $12-14 \times 3.5 \mu$ . The spores of *B. indecicus* are likewise elliptical to fusiform-elliptic, but inclined to be more elliptical than fusiform, and measure  $10-15 \times 3.5-4 \mu$ , with a few occasionally up to  $20 \times 5 \mu$ , but mostly  $10-12 \times 3.5-4 \mu$  (that is, somewhat shorter and broader).

A large to very large sporophore with rosaceous tubes and spore print will in all probability be *B. felleus*. The taste may be mild, especially if there has been very rapid growth in rainy weather, although a prolonged test will usually disclose at least a trace of the bitterness. A smaller sporophore of this species will almost invariably be quite bitter to the taste after a very short test. If the taste of a small plant is mild, the flesh will be very firm by comparison with *B. felleus*, but if there is still question, the shorter and slightly broader, more elliptical rather than subfusiform spores, will in my experience give a safe determination.

*Boletus crassipes*, *B. badiceps* and *B. eccentricus*

Peck described four species from notes and drawings sent by McIlvaine. Whether or not Peck saw the dried specimens is not known, but at any rate there are no types extant. Accordingly, Murrill excluded three of these species from his treatment—*B. eccentricus*, *B. badiceps* and *B. fulvus*. He made *B. crassipes* questionably a synonym of *B. affinis*.

In as much as the lack of type specimens has been the only thing that has kept them from legal recognition, it has been my hope that I might find them and re-establish them as valid species. My efforts were rewarded this last summer by my coming across three of them. *B. crassipes* was found at Mt. Gretna, Pa., and *B. badiceps* at Ridgewood, Pa. by Miss Esther A. Dick and myself. *B. eccentricus* was collected in Greenville, R. I., by Mrs. Florence H. Hayward.

Of *B. crassipes*, Peck said that it is distinguished by the thick, beautifully reticulated stipe, the deep velvety brown color of the pileus and the yellow color of the flesh. It may be added also that the stipe is described as rather short and the pileus as projecting beyond the tubes. Hence, of course it bears no resemblance to *B. affinis*, but it does strongly suggest *B. auripes* Peck. The latter species has a brown pileus, yellow flesh, stipe yellow and reticulate, although usually not so extensively reticulated as that of *B. crassipes*. The stipe is usually longer than described for *B. crassipes*, but in some of my specimens of *B. crassipes*, the stipes were no thicker than the thinnest of *B. auripes*. Further, I have thus far been able to find no differences in the spores of the two species.

It may be that *B. crassipes* is a good species characterized by deeper brown pileus, flesh yellow not fading to white (as in *B. auripes*), and stipe more orange-yellow, more extensively reticulated, shorter and usually thicker. On the other hand, it may be found that *B. auripes* is more variable in color and proportions than now known and that these two species are the same, in which case the name *crassipes* would disappear as a synonym because of the priority of *auripes*. The two species must now be left distinct, however, until further study of more specimens of both can be made.

*B. badiceps* has a fine velvety appearance to the naked eye, but the surface is glabrous and not at all subtomentose. For this reason it more properly belongs in the tribe Subpruinosi, if one follows the Friesian system, rather than in the Subtomentosi, where it was placed by McIlvaine. The color of my specimens was bay red to somewhat chocolate brown; I did not see any dark maroon forms. The truncate or bevelled margin is usually

noticeable, although it often is not so pronounced as McIlvaine stated. The stipes were subbulbous and not ventricose and not markedly radicating. McIlvaine's figure 2 in plate CXVI<sup>3</sup> shows no real radicating base. In color, the stipes of my sporophores were whitish pallid at the apex and below were tinged dingy yellow and in places streaked with reddish or brownish. They were slightly reticulate at the very apex, because of the decurrent walls of the tubes and within they were fibrous-hollow, perhaps from rapid growth after heavy rains.

The spores are ochraceous brown to ferruginous in mass, yellow to deep yellow under the microscope, subfusiform to elliptical and more or less irregular, and measure  $10-20 \times 4.5-6.5 \mu$ , mostly  $12-14 \times 4.5 \mu$ . The cystidia are either fusiform and hyaline or irregularly clavate and deep yellow, measuring  $40-60 \times 7-8 \mu$ .

*B. eccentricus* may be gray, yellowish-gray or brownish ochraceous sometimes sparingly tinged reddish. The tubes are yellow to brownish-yellow. The stipe may taper upward or downward, may be somewhat rugose or striate, and is white-reticulate. The spores are ochraceous in mass, pale brown under the microscope, in shape elliptical to fusiform or subfusiform and measure  $10-17 \times 4-5 \mu$ , mostly  $12-14 \times 4.5 \mu$ . The cystidia are bulbous-clavate to ventricose-rostrate or fusiform, hyaline,  $40-50 \times 10-14 \mu$ .

*B. crassipes* Peck is, therefore, now represented by specimen no. 270 in my herbarium at Brown University, *B. badiceps* by number 300 and *B. eccentricus* Peck by number 221. Water-color drawings of all three are contained in my collection.

#### NEW SPECIES

##### ***Boletus turbinatus* sp. nov.**

Pileo crasso, turbinato, convexo, applanato vel depresso, sicco, tomentoso, ochraceo-brunneo vel paulo rubro-brunneo, 4 cm. lato; carne dilute citrina, infra cutem rubra, cyanescente, demum atro-rubra; tubulis adnatis vel decurrentibus, flavis, minutis, angulatis; stipite breve, deorsum attenuato, e levi paulo striato, dense furfuraceo, apice flavo, basi atro-rubescens, solido; sporis valde flavis sub lente, late fusiformibus paulo ellipsoideis,  $13-21 \times 5-7 \mu$ .

<sup>3</sup> One Thousand American Fungi. 1900.

Pileus rather thick so as to make entire plant more or less turbinate, convex to applanate or depressed, 4-7 cm. broad. Surface dry, minutely tomentose to bunchy tomentose, ochraceous-brown to more or less reddish-brown (russet to Kaiser brown). Flesh light lemon yellow, reddish under the pellicle, changing to blue when cut and later becoming mahogany reddish. Tubes convex in mass, adnate to subdecurrent, at first light yellow, then dull yellow, 7-13 mm. or more long; mouths angular, 1-2 to a mm., slightly orange tinged. Stipe short, tapering downward, even to more or less striate, densely furfuraceous, yellow at apex to brownish Morocco red at base; within solid, light lemon yellow, changing to blue and later to mahogany; 1-2 cm. long, 7-10 mm. thick at apex, 4 mm. at base. Spores probably dark ochraceous-brown in mass, deep dull yellow under the microscope, broadly fusiform, few elongate or nearly ellipsoid,  $13-21 \times 5-7 \mu$ , mostly  $14 \times 5-6 \mu$ . Cystidia ventricose or fusiform-irregularly-rostrate, hyaline to yellow,  $40-75 \times 7-8 \mu$ .

Collected at Valley Park, Mo., by D. H. Linder. No. 345 in Herb. WHS, also in Herb. D. H. Linder.

In many ways similar to *B. chrysenteron*; differs in the more turbinate shape of the entire plant, lack of ochraceous or olivaceous tints to the pileus and not being red-cracked, in the tubes not changing to blue, the spores broader, more fusiform and deeper yellow, and the irregularly beaked, yellow cystidia.

### ***Boletus subdecorus* sp. nov.**

Pileo paullulum firmo, convexo vel plano-convexo, sicco, glabro, impolito, fusco-umbrino rubrotincto, 5-7 cm. lato; carne firma, alba, fracto dilute incarnescente; tubulis adnatis vel liberis, albis, parvis minutisve, subrotundis, tactis ferruginescentibus; stipite flexuoso, subinde excentrico, subbulboso et sursum attenuato, levi, apice paullulum reticulato, e glabro minute furfuraceo, concolore, apice albido, solido, fibroso; sporis ochraceo-brunneis, hyalinis sub lente, subfusiformibus vel ellipsoideis,  $10-15 \times 3.5-5 \mu$ , plerumque  $14 \times 4 \mu$ .

Pileus rather firm, convex to plano-convex, 5-7 cm. broad. Surface dry, dull to dull shiny, velvety appearing when fresh but glabrous, dark brown to chocolate-brown, sometimes tinged reddish. Flesh firm, pure white, sometimes becoming light flesh color when cut. Tubes adnate to free, white becoming more or less brownish flesh-color when wounded or in age, about 1 cm. long; mouths small to minute, subrotund, white, changing to rusty-brown where touched or in age. Stipe flexuous, perhaps somewhat eccentric, more or less bulbous and tapering upward,

even, perhaps slightly reticulate at the very apex, glabrous to minutely furfuraceous, reddish-brown to chocolate-brown, sometimes more or less streaked, perhaps paler to whitish at the apex and base; within, solid, fibrous, white; 7-9 cm. long, 15-30 mm. thick. Spores ochraceous-brown in mass, hyaline under the microscope, subfusiform or perhaps elliptical,  $10-15 \times 3.5-5 \mu$ , mostly  $14 \times 4 \mu$ . Cystidia truncate-clavate, fusiform or ventricose-rostrate, hyaline or yellow,  $40-60 \times 7-9 \mu$ . Odor and taste mild to mildly farinaceous.

Under oaks, Livingstonville, New York. July to September. No. 121 in Herb. WHS.

This species somewhat resembles *B. decorus* Frost, which to my knowledge has not been found by anyone since Frost except McIlvaine. *B. subdecorus* differs in the pileus being glabrous instead of subtomentose, and in the tubes being white and becoming rusty, instead of yellow changing to greenish. It apparently belongs in the *Edules*.

***Boletus pseudodecorus* Snell & Dick, sp. nov.**

Pileo paullulum firmo, e convexo plano-convexo, sicco, e pruinoso minute tomentuloso velutinove, in maculis glabro, fuscocumbrino rubrotincto, 5-8 cm. lato; carne molle, alba; tubilis adnatis, albis, fusciscentibus, parvis, rotundis; stipite subcurvato, subinde excentrico, supra reticulato, dense furfuraceo vel subtomentoso, rare pruinoso, saepe apice glabro, et basi tomentoso, concolore; sporis ochraceo-brunneis, hyalinis sub lente, ellipticis vel subfusiformibus,  $8-14 \times 3-3.5 \mu$ , plerumque  $8-10 \times 3.5 \mu$ .

Pileus rather firm, convex to plano-convex, 5-8 cm. broad. Surface dry, pruinose to very minutely subtomentose or minutely velvety, glabrous in spots, dark brown to chocolate-brown. Flesh soft, pure white, unchanging. Tubes adnate, white, becoming more or less brownish with age, up to 1 cm. long; mouths small, rotund, white, becoming brown like the pileus in age or on drying. Stipe more or less curved, perhaps eccentric, reticulate more than half the length, densely furfuraceous to minutely velvety or minutely subtomentose, rarely pruinose, perhaps glabrous at apex, often tomentose at base, dark brown to chocolate brown like pileus; within solid, white; 4-6 cm. long, 10-17 mm. thick. Spores ochraceous-brown in mass, hyaline under the microscope, elliptical to subfusiform,  $8-14 \times 3-3.5 \mu$ , mostly  $8-10 \times 3.5 \mu$ . Cystidia truncate-clavate to somewhat ventricose-rostrate, few hyaline, most deep yellow,  $25-70 \times 6-12 \mu$ . Odor and taste mild, perhaps somewhat farinaceous.

Under hardwoods, mostly oaks. Mt. Gretna, Pa. August and September. No. 272 in Herb. WHS.

This species closely resembles *B. subdecorus* in general appearance, but differs in the pruinose to subtomentose pileus, reticulate stipe and smaller spores. It differs from *B. decorus* Frost in its white tubes, reticulate stipe and smaller spores. It apparently belongs in the *Edules* with these other species.

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## SEX-REACTION LINKAGE IN NEUROSPORA

F. L. TAI<sup>1</sup>

In his studies on the inheritance of response to heat-treatment in *Neurospora* Lindegren (5) found in a certain hybrid that the spores which germinated without heating were all non-conidial, and usually of sex-reaction type A. He has also proved (7) that the "pale" and "non-pale" factors in *N. crassa* are linked with the reaction factors. Recently Dodge (4) has pointed out that the factors for orange-colored conidia in *N. tetrasperma* may be linked with the reaction factors. At the suggestion of Dr. Dodge the writer has undertaken to repeat his experiments and also to analyze progeny from the mating S1  $\times$  S9, the ancestral stock of the irradiated lines, to determine whether or not a linkage actually exists. The results of the writer's experiments show beyond doubt that the factors for the orange-color of the conidia in *N. tetrasperma* are linked with the sex-reaction factors as are also the factors for darkening of the substratum. In these experiments because of the limited time available for this work only the gross characters are dealt with, further work with a standard medium and a uniform set of environmental conditions should bring out other similar linkages.

### MATERIALS AND METHODS

Single ascospores were germinated and isolated in the usual way from the progenies of the matings S1  $\times$  S9, 9.7C4  $\times$  S1 and 9.7C8  $\times$  S9. Numbers 9.7C4 and 9.7C8 are races from the irradiated line G5.3 (3). After isolation these mycelia were first grown on corn meal agar to determine whether they were unisexual. The unisexual ones were then grown on dextrose agar to

<sup>1</sup> This work was done at The New York Botanical Garden during the tenure of a Research Fellowship from the China Foundation for the Promotion of Education Culture. The writer is greatly indebted to Dr. B. O. Dodge who suggested the problem and who provided some of the material and cultures and tendered critical advice. Thanks are also due to the authorities of The New York Botanical Garden for laboratory and library facilities.

bring out the linkage characters. Five days are usually required for the full expression of these characters, but they are often evident within three days. The races were then tested for their sex-reaction with tester strains. Finally the progeny from the matings  $9.7C4 \times S1$  and  $9.7C8 \times S9$  were analyzed. Unisexual component conidial strains from bisexual isolations from these matings and also from those of  $S1 \times S9$  were separated out and studied.

#### PROGENY FROM THE MATINGS OF $S1 \times S9$

In the crosses of either  $S1$  or  $S9$  with any one of the opposite sex-reaction of the irradiated lines such as  $9.7C4$  or  $0.7C8$  as already pointed out by Dodge (4) the orange-color of the conidia is inhibited from expression in the offspring in which the lethal factor is present. In the progeny from the matings of  $S1 \times S9$ , the ancestral stock of the x-rayed lines, the expression of the linked factor is not interfered with. The fact that race  $S1$  always produces more orange-colored spores than  $S6$ , a sister race of  $S9$ , was first observed by Dodge (1, 2), but it has not yet been proved that the factors responsible for this difference are linked consistently with the sex-reaction factors. The race  $S9$  as we shall see is occasionally fluffy and produces quite an abundance of conidia, but the conidia are never bright orange-colored. The cause for the occasional fluffiness in  $S9$  is unknown. The writer believes that the principal sex-reaction linkage involved in  $S1$  is the factor for the orange-color of the conidia. Thus, when the races  $S1$  and  $S9$  were grown separately on dextrose agar<sup>2</sup> they show the following cultural characters:

$S1$  (a)—Fluffy, with abundance of orange-colored conidia; substratum not blackened.

$S9$  (A)—Mycelium usually applied closely to the substratum with few conidia; substratum blackened. Occasionally fluffy with quite an abundance of pale pinkish lilac- (never orange-) colored conidia.

Of a total of sixty-nine single-spore isolates from the matings of  $S1 \times S9$ , thirty-two gave the cultural characters of  $S1$  on dextrose agar, thirty-five those of  $S9$ . The other two strains

<sup>2</sup> Difco's hacto dextrose agar was used throughout these experiments.



showed the cultural characters of both S1 and S9. When they were tested for sex-reactions the races in the first group all proved to be of the sex-reaction **a**, while those of the second group were of the reaction **A**. All the bisexual spores isolated, when grown on dextrose agar, produced the orange-colored conidia like race S1. Races 19.31 and 92 of the third group, however, showed characters as noted of both of the parental stocks, that is, they produced on dextrose agar an abundance of orange-colored conidia, and the substratum turned black. Because of these characters they were at first taken to belong to the group giving reaction **a**. But it was proved to be otherwise when they were tested out. These represent the only two cross-overs out of the sixty-nine isolates. In these two the orange-color of the conidia did not remain at a constant shade in numerous tests. It failed to show up in some of the transfers. This seems to indicate that environmental conditions had a great deal to do with the above inconsistency.

Fifteen unisexual conidia were isolated from the bisexual mycelium T17. Three of the fifteen isolates showed on dextrose agar the characteristics of S9, while the rest were like S1. Those showing the characters of S9 gave the reaction **A**, the others the reaction **a**.

The unisexual single-spore isolates from the matings  $S1 \times S9$  are given below according to their sex-reactions:

Sex-reaction **a**: 1, 4, 6, 12, 18, 20, 21, 17.1, 19.24, 26, 37, 39, 40, 48, 50, 59, 60, 62, 64, 68, 71, 91, 93, 94, 95, 98, 61, 66, 4.43.3, 4.43.6, Tet. G, Tet. G<sub>4</sub>.

Sex-reaction **A**: 16, 17.2, 19.31, 22.4, 22.10, 33, 34, 44, 46, 45, 56, 57, 75, 87, 88, 89, 90, 92, 73, 77, 65, 78, 144, 120, 23, 85, S3, S6, S13, 4.43.10, 4.43.8, 4.43.13, Tet. G<sub>2</sub>, Tet. G<sub>3</sub>, Tet. G<sub>5</sub>, Tet. G<sub>6</sub>.

Although the number of the isolates under test was not large, it was enough to show that the factor **O** for orange-color of the conidia is rather strongly linked to **a**, and the factor **M** for blackening of substratum is strongly linked to the factor **A**.

The blackening of the substratum is due to the diffusion of some black substance from the old mycelium.

PROGENY FROM THE MATINGS 9.7C4  $\times$  S1 AND 9.7C8  $\times$  S9

This set of experiments was only a repetition of what Dodge (4) had done. It differs from the work with the S1 and S9 races in that 9.7C4 and 9.7C8 are progeny from irradiated lines. Altogether one hundred and fifty-two unisexual single ascospore isolates were analyzed. According to their gross cultural characters they may be grouped into seven classes:

1. **AM(ol)**—Mycelium applied to substratum, conidia very few, occasionally fairly fluffy, brownish black masses of irregular size at the base of the slant, substratum becoming brownish black. 9.7C4  $\times$  S1: T39, T43, T54, T130, T127, T149, T183, 8, 14, 16, 48. 9.7C8  $\times$  S9: T13.2, T104, T128, T144, T147, 2, 6, 16, 17, 28, 35, 38, 50.
2. **AM(oL)**—Mycelium closely applied to the substratum as a white covering over the medium or more or less fluffy, conidia few or fairly abundant, pinkish lilac in color, substratum blackened. 9.7C4  $\times$  S1: T4, T14, T22, T45, T48, T55, T74, T92, T123, T128, T134, T132, T135, T129, T144, 1, 4, 25, 27, 30, 31, 44, 35. 9.7C8  $\times$  S9: T23.2, T63, T100, T108, T111, T125, T148, T168, 29, 30, 31, 40, 41, 49, 50, 55.
3. **am(OL)**—Fluffy (rarely not), abundance of bright orange-colored conidia, substratum clear orange-colored. 9.7C4  $\times$  S1: T5, T11, T28, T31, T42, T49, T52, T64, T78, T80, T81, T95, T126, T133, T137, T75, T142, T15.1, 10, 12, 23, 36, 38, 40, 42, 45, 46, 50, T57.1. 9.7C8  $\times$  S9: T13.1, T112, T114, T127, T133, T135, T137, T120, T105, T101, T134, T162, T174, T178, T150, 5, 12, 23, 43, 44.
4. **am(Ol)**—Mycelium applied to substratum, conidia usually few, sometimes scanty pinkish conidia on the surface of the slant, brown or amber-colored masses of irregular size at the base of the slant, substratum becoming brown or amber-colored. 9.7C4  $\times$  S1: T10, T16, T44, T68, T102, 2, 3, 26, 34, 39, 43. 9.7C8  $\times$  S9: T8, T22, T28.1, T69, T73, T113, T131, T106, T109, T152, T159, T163, T183, 8, 11, 10, 18, 21, 26.
5. **am(Ol)**—Fluffy orange-colored conidia, substratum dark brown. 9.7C8  $\times$  S9: T118 and T121.

6. **Am(oL)?**—Mycelium applied to the substratum, conidia few or fairly abundant, substratum not blackened. 9.7C4  $\times$  S1: T70, 41. 9.7C8  $\times$  S9: 48.
7. **Am(ol)?**—Mycelium applied to the substratum, conidia few, substratum not blackened. 9.7C8  $\times$  S9: 20, 36, 45, 47.

The genetic constitution of these seven classes as far as could be determined is given above. Symbols **A** and **a** are for sex-reactions, **O** for orange-color of conidia, **M** for blackening of substratum and **l**, for the lethal factor. All of the isolates except two producing fluffy mycelium and orange-colored conidia fall into the third class which gives the sex-reaction **a** and where the recessive lethal factor, **l**, is absent. In the fourth class of the same sex-reaction the factor **O** did not express itself on account of the presence of the lethal factor as was expected. But the races T118 and T121 of the fifth class from the matings of 9.7C8  $\times$  S9, although seemingly having the same genetic constitution as those in the fourth class, are fluffy and produce an abundance of orange-colored spores. The lethal factor in them does not seem to be effective in inhibiting the expression of the factor **O** for orange-color of the conidia.

In the strains 41, T70 (9.7C4  $\times$  S1), 20, 36, 45, 47 and 48 (9.7C8  $\times$  S9) which are of the reaction **A**, the melanistic factor, **M**, which is usually linked with this sex-reaction seemed to be absent. In the other progeny of the reaction **A** from the crosses of 9.7C4  $\times$  S1 and 9.7C8  $\times$  S9 it was found in a few cases such as in the races T45, 44, 4 (9.7C4  $\times$  S1) 29 and 30 (9.7C8  $\times$  S9) that the melanistic factor **M** is, in fact, a variable one. The reason that the strains, 41, T70 (9.7C4  $\times$  S1) 20, 36 etc. (9.7C8  $\times$  S9) all had a non-blackened substratum might be due to the fact that the environmental conditions to which they were subjected were not best for the expression of the black character as Lindegren has pointed out for the **M** factor. A case of crossing-over of the **M** factor in these races was, therefore, a doubtful one.

Since the unisexual single spore isolations from the crosses of 9.7C4  $\times$  S1 and 9.7C8  $\times$  S9 only amounted to one hundred and fifty-two, the ratio of the number of the matings producing perithecia with ascospores to the number of those producing perithecia with aborted asci, and the ratio of the number of

cultures not showing orange-colored conidia to the number of those showing them was not 3 : 1 in either case as must be expected with larger numbers.

#### OTHER SPECIES OF *NEUROSPORA*

The writer has also grown races of other species of *Neurospora* on dextrose agar to see whether they will also show different cultural characters for different sex-reactions. The species tested are the following: *N. sitophila*, *N. crassa*, *N. intermedia*, *N. Toroi* and a four-spored strain of *N. tetrasperma* collected in Texas by Mr. M. B. Morrow and sent to this laboratory by Dr. Charles Thom. The cultural characters they produced are given below.

1. *N. sitophila* 56.4 and 56.8—Fluffy, an abundance of salmon pink-colored conidia. No apparent difference in the cultural characters shown by the strains of different sex-reactions.

2. *N. crassa*—Fluffy, an abundance of salmon pink-colored conidia (pinker than *N. sitophila*) substratum not blackened. No apparent difference in the cultural characters shown by our tester strains of different sex-reactions.

3. *N. intermedia*—strain of reaction **a**—Fluffy, an abundance of saffron-colored conidia; sclerotium-like bodies abundant.

4. *N. Toroi*—**a**—Fluffy, conidia fairly abundant, yellowish, substratum not blackened. Strain **A**—Less fluffy than strain **a**, conidia fairly abundant, yellowish, substratum blackened.

5. Morrow strain—**a** (T21)—Fluffy, an abundance of orange-colored conidia, substratum somewhat blackened.

Morrow strain **A** (T23)—Fluffy, an abundance of orange-colored conidia, substratum somewhat blackened, more so than in T21 **a**; many large sclerotium-like bodies produced.

From the above it will be seen that in *N. Toroi* the factor for the blackening of substratum may be linked with the sex-reaction **A**, and in the Morrow strain the factor for producing sclerotium-like bodies in the strain of the sex-reaction **A** may also possibly be a sex-reaction linkage.

#### DISCUSSION AND SUMMARY

It is evident from what has been given above that the fungi under test seem to be very sensitive in their response to a slight variation in the environmental conditions. The inconsistency of

certain characters in the above experiments may be attributed to this cause. Regarding the variability of the melanistic factor in the few cases mentioned before, Lindegren (6) has also reported that in *N. crassa* the upper surface of the substratum became black on concentrated corn meal agar and that this did not occur on dilute corn meal agar.

In the progeny of the mating  $S1 \times S9$  the gene **O** for orange-color and that for sex-reaction **a** remain together in over 97 per cent of the f1 gametes. The gene for blackening of substratum and that for the sex-reaction **A** remain together in 100 per cent of the f1 gametes. The factor **M** seems to be even more strongly linked to sex-reaction **A** than the factor **O** is to reaction factor **a**.

With regard to the offspring of the crosses of  $9.7C4 \times S1$  and  $9.7C8 \times S9$ , the fact that all of the isolates producing orange-colored conidia are of the sex-reaction **a**, and that all of those with blackened substratum, with the exception of only two doubtful cases, are of the opposite reaction **A**, shows also unmistakably the existence of strong linkages. The exceptional activity of the factor **O** for orange-color of the conidia in the races T118 and T121 in spite of the presence of the lethal factor **l**, must have been due to the non-functioning of the lethal for some unknown reason. A sudden change in the lethal gene might have taken place. This change has not, however, inactivated its power to produce ascus abortion.

THE NEW YORK BOTANICAL GARDEN

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# AN UNDESCRIBED SPECIES OF TAPHRINA ON CHINQUAPIN

ANNA E. JENKINS

(WITH 1 FIGURE)

The present taxonomic study of *Taphrina* on chinquapin (*Castanopsis chrysophylla* DC.) was initiated by the contribution of specimens from J. S. Boyce, which he gathered near Dorrington, Calaveras Co., California, on Aug. 16, 1934. The fungus was said to be abundant on young leaves in this region. Although not newly discovered it has not been collected for many years, and, as will be explained later, is evidently undescribed.

The *Taphrina* was first collected by Harkness<sup>1</sup> about 50 years ago. Identifying it as *Ascomyces Quercus*, he reported it along with this species on *Quercus* as follows:

"*Ascomyces Quercus*, Cooke.—On leaves of *Quercus Douglasii*, Folsom, and *Castanopsis chrysophylla*, Sierra Nevada, May–August. 3203, 3294."

Specimen 3294 is possibly not available at present. Through correspondence with J. T. Howell of the California Academy of Sciences, Lee Bonar of the University of California, F. J. Seaver of The New York Botanical Garden, and D. H. Linder of the Farlow Herbarium of Cryptogamic Botany, Harvard University, it has been learned that it is not at any of these institutions. Patterson<sup>2</sup> refers to a specimen sent her by Harkness, but a complete citation of the specimen is not given, and so far as known this is also not available.

There are at hand, however, two specimens of the fungus representing other early collections. These were gathered at Sisson, Siskiyou Co., Calif., in July and August, 1894, by Marshall A. Howe. The specimen collected in July is represented in

<sup>1</sup> Harkness, H. W. Fungi of the Pacific Coast, IV. Bull. Calif. Acad. Sci. 1: 1–13, 1885.

<sup>2</sup> Patterson, F. W. A study of North American parasitic Exoascaceae. Bull. Lab. Nat. Hist. State Univ. Iowa 3: 89–135, 1895.

the Herbarium of the University of California,<sup>3</sup> as well as in The New York Botanical Garden, and the other in the Mycological Collections of the Bureau of Plant Industry, United States Department of Agriculture. All are labeled "*Taphrina castanicola* E. & E. n. sp." The specimen in the Mycological Collections, Bureau of Plant Industry is accompanied by the following note in Ellis' handwriting:

"*Taphrina castanicola* E. & E. is the same as the *Taphrina quercus* of Harkness' Catalogue,<sup>4</sup> but it seems to me to be different from that species and we have called it *T. castanicola*. If the host is really *Castanopsis*, *T. Castanopsidis* would be better, but Prof. Howe of the University of California who sent this specimen said 'on *Castanea chrysophylla*,' hence the name *T. castanicola*. Perhaps you had better write Prof. Howe and see what he says of the host name." To whom these remarks were addressed is not known. The leaves of both specimens are definitely of *Castanopsis chrysophylla*, which was originally described as *Castanea chrysophylla* Douglas.

Howe's specimens most certainly were collected too late to have been considered in Patterson's treatise on the Exoascaceae; under *Taphrina coerulescens* (Mont. & Desm.) Tul. she discusses there the *Taphrina* on *Castanopsis* sent her by Harkness as follows:

"Upon the affected areas which may constitute one-half of the leaf surface the asci are closely crowded together; they are in size near the minimum measurements of *T. coerulescens* and have only one process extending very slightly between the epidermal cells, but there seems to be no difference of sufficient importance to constitute even a variety of the species under consideration."

On the basis of material studied by the writer the fungus is clearly distinct from *Taphrina coerulescens*. The asci are cylindrical rather than club-shaped as in that species, as well as longer and narrower. The fungus is evidently a distinct species as stated by Ellis in the note quoted above. Since no diagnosis was given by Ellis and Everhart for the fungus it is here described as new under the specific name proposed by them:

<sup>3</sup> Information sent by Lee Bonar, in a letter dated Apr. 15, 1935.

<sup>4</sup> The article by Harkness already cited is evidently referred to here.

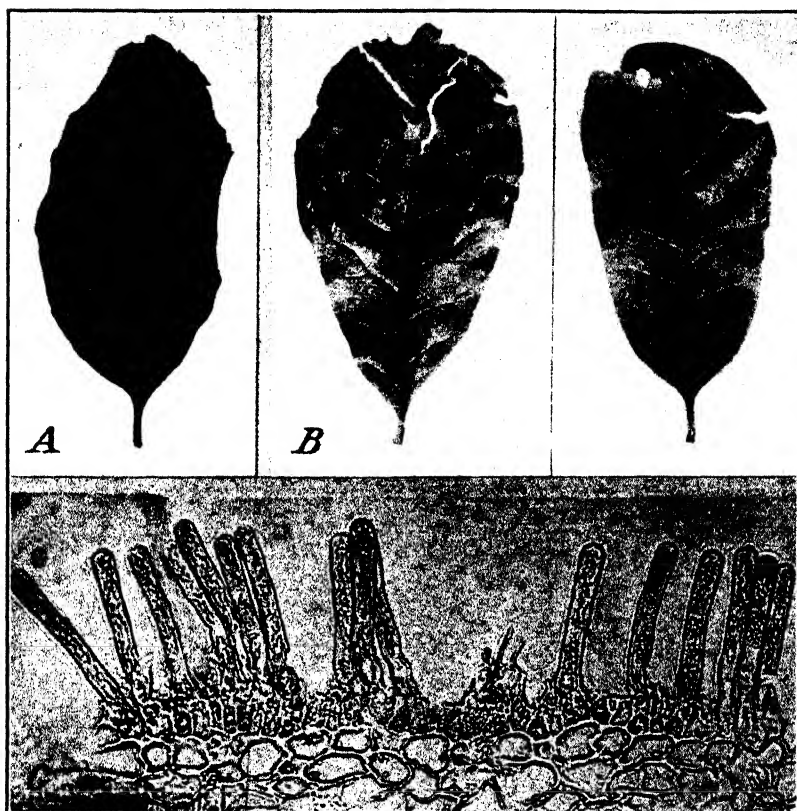


FIG. 1. *Taphrina* on *Castanopsis chrysophylla*: A and B, lower surfaces of leaves from (A) Sisson, Calif., July, 1894, M. A. Howe, and (B) from the vicinity of Dorrington, Calif., Aug. 16, 1934, J. S. Boyce ( $\times 1$ ); C; hymenium on lower surface of leaves from specimen shown in A ( $\times 200$ ); photographs by M. L. F. Foubert.

***Taphrina Castanopsidis* sp. nov. Ellis & Ev. (in herb.)**

Hymenium hypophyllous; asci standing close together, cylindrical, rounded at apex, entire structure reaching 80 to 165  $\mu$  in length, upper exposed part 13–17  $\mu$  in diam., basal part extending slightly between the epidermal cells, not modified, or variously formed, more or less pointed, truncate, bent out of line with the rest of the structure, or enlarged reaching 26  $\mu$  in diam., sometimes uneven or with 2 or 3 lobes up to 10  $\mu$  in length and occasionally a slender, somewhat curved process reaching 40  $\mu$  in length; ascospores 8 in number, up to 10  $\mu$  in diam.; sprout conidia 3–5  $\mu \times 1.5$ –2.5  $\mu$ ; asci filled with sprout conidia or those that have borne sprout conidia often purplish.



Hymenio hypophyllo; ascis dense confertis, cylindraceis, apice rotundatis, totis (basi includente) 80–165  $\mu$  longis; parte superiore exposito 13–17  $\mu$  diam.; parte basali intra cellulas epidermicales paulo extendente, immutata vel varie formata, plus minusve acuta, truncata, inflexa vel inflata, usque 26  $\mu$  diam., interdum irregulari vel 2–3-lobata, usque 10  $\mu$  longa, interdum processu curvato 40  $\mu$  longo praedita; ascosporis octonis, usque 10  $\mu$  diam.; conidiis secundariis 3–5  $\mu \times$  1.5–2.5  $\mu$ ; ascis conidia continentibus vel vacuis saepe purpureis.

Distribution: On young leaves of *Castanopsis chrysophylla*, affecting part or the entire leaf surface, diseased areas on lower surface of leaf brown and yellowish green on upper surface, often concave below and convex above. California.

*Collections examined*: Sisson, Siskiyou Co., Calif., M. A. Howe, July 1894 (ex Univ. Calif. Fungi of Calif. 121, in Herbarium of The New York Botanical Garden); August 1894 (in Mycological Collections, Bureau of Plant Industry). Dorrington, Calaveras Co., Calif., Aug. 16, 1935, J. S. Boyce (ex Herb. J. S. Boyce 2287).

*Type*: In Mycological Collections, Bureau of Plant Industry.

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## CULTURAL STUDIES OF THREE NEW PYRENOMYCETES<sup>1</sup>

L. E. WEHMEYER

(WITH 3 FIGURES)

Among the specimens of the stromatic Pyrenomycetes kindly sent to the writer by various workers, there have been a number which have been difficult to determine or apparently undescribed. There is already so much confusion in many of the genera of this group, however, that the writer feels great reluctance in the description of new species. In many cases a monographic study of a genus is necessary to even determine what are specific limitations. The three cases here treated are so clear cut, however, that there seems to be little doubt of their individuality.

### ENDOTHIA VIRIDISTROMA

In April of 1934, a *Valsa*-like fungus was collected by Dr. J. H. Miller on *Cercis canadensis* on the campus of the University of Georgia at Athens and sent to the writer for determination. The strongly developed, colored stroma and the polystichous arrangement of the perithecia (FIG. 1) excluded the plant from the genus *Valsa*, and the hyaline spores and non-sulcate ostioles eliminated the possibilities of its being an *Eutypella*. The remaining possibility was the genus *Endothia*, with which its characters were in close agreement. Both Fries (1, p. 385) and Shear (2, p. 14), in their generic descriptions of *Endothia*, give the stromata as being some shade of yellow, orange or red, and so far as the writer has been able to discover no species of *Endothia* with greenish stromata has been described. The difference in color does not seem sufficient to the writer for generic separation. This material was sent to Dr. C. L. Shear for his opinion and he too agreed that it was con-generic with *Endothia* and should not be excluded on the basis of color, but expressed the desirability of a knowledge of the conidial stage as further evidence.

<sup>1</sup> Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 549.

The writer had intended to culture the fungus, if possible, and on October 10, 1934, ascospores were sprayed onto nutrient agar. Within twenty four hours, these spores had become greatly swollen, globose and measured  $9-11 \times 7.5-8.3 \mu$ . One or two thick germ tubes, some  $5 \mu$  in diameter were pushed out from each spore (FIG. 3: 5). These germ tubes grew in a tortuous manner and soon branched several times. Transfers from single spore colonies onto oatmeal agar produced a coarse matted, cottony growth on the surface which was white to grayish-white or yellowish at first but became yellowish-green to a deep dull green with age.

After several weeks growth, a few spherical, superficial stromatic pycnidia were formed, which increased in size up to about 1 mm. in diameter. These stromata were clothed externally with a grayish tomentum. Internally they consisted of an interwoven compacted mass of rather thick walled greenish-yellow prosenchyma, the hyphae of which were  $1.5-2 \mu$  in diameter. Each stroma contained a number of angular, flask shaped to irregular cavities, all of which emptied into a common ostiole or mouth through which the numberless conidia were exuded as a single, yellowish, thread-like spore horn. These cavities (FIG. 3: 3) were  $200-300 \times 200-400 \mu$  and possessed a definitely differentiated wall of dark yellow- or olive-brown pseudoparenchyma which separated easily from the surrounding stromatic tissue. The inner cells of this wall were lighter in color, were filled with a denser protoplasm and gave rise to numerous, simple or fasciculately branched conidiophores which were somewhat swollen at the base and measured  $8-11.5 \times 1-2 \mu$ . From the apex of these conidiophores, minute cylindric to allantoid, hyaline, one celled conidia, measuring  $2.5-3(3.5) \times 0.8-1 \mu$  were abstricted in large numbers (FIG. 3: 1). When sprayed onto nutrient agar, these conidia germinated abundantly within twenty four hours. They also swell enormously before germination (FIG. 3: 2), reaching a size of  $6.5-7.5 \times 8-8.5 \mu$  and showing a somewhat thickened wall. The single germ tube formed is  $3.5-5 \mu$  in diameter.

On November 14, steam sterilized twigs of *Fagus grandifolia* and *Carpinus caroliniana* were inoculated from single spore

cultures. Similar hemispheric, grayish-green, superficial, pycnidial stromata, exuding single yellowish spore horns, were formed on these twigs, but no perithecial stromata were ever seen.

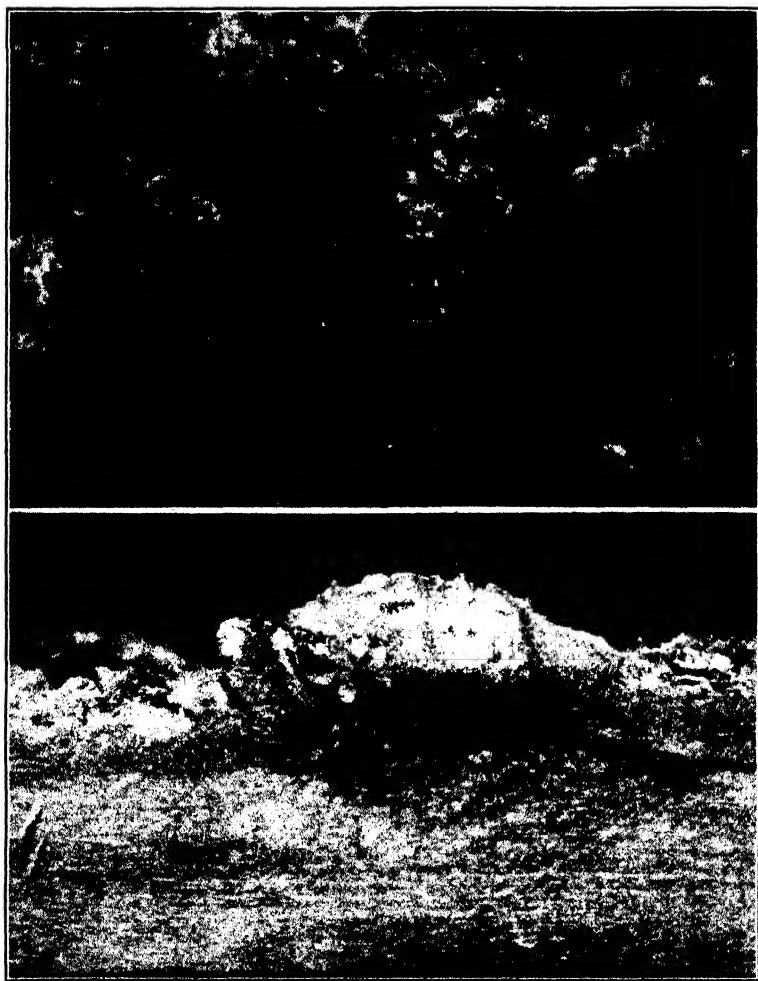


FIG. 1. *Endothia viridistroma*: upper figure, surface view of stromata and ostioles ( $\times 8$ ); lower figure, radial section through perithecial stroma ( $\times 20$ ).

These ectostromata on twigs originate within or just beneath the periderm but at maturity, when they reach a diameter of 1 mm., they may include the bark cortex as deep as the first layer of

stone cells. In section, the pycnidial cavities are more numerous and more regular in outline than on agar and the walls may lie loose within the more or less disintegrated stroma.

These conidial stromata agree very well, in general, with the type of pycnidial formation found in other species of *Endothia*. The pycnidial stromata in this species differ chiefly in having larger and more distinct pycnidial locules than in the species of *Endothia* with orange colored stromata. This plant is therefore described as a new species:

***Endothia viridistroma* sp. nov.** (FIG. 1 AND 3: 1-6)

The stromata (FIG. 1, upper fig.) appear on the surface as widely erumpent, rather superficial, blackened, often confluent masses, 2-5 mm. in diameter and 1-1.5 mm. thick. The surface of the stroma is thickly beset with black, elongate, spine-like, often tortuous ostioles, up to 1 mm. in length, which are easily broken off. In section (FIG. 1, lower fig.), the stroma is seen to be dark green to yellow green within and largely erumpent superficial. The stroma penetrates slightly into the bark cortex and remainders of cortex cells can be seen in the superficial portion, which is probably entostromatic in origin. The perithecia are polystichous in their arrangement in the upper portion of the stroma. They are often radially elongated, small,  $200-350 \times 150-250 \mu$  and with long narrow necks which emerge as the bristly ostioles. The asci (FIG. 3: 6) are numerous, small, clavate, non-stipitate,  $15-20 \times 3-4 \mu$ . The spores (FIG. 3: 4) are biserial, minute, hyaline, one-celled, very slightly allantoid or slightly swollen and then almost ellipsoid, and  $5-6 \times 1-1.5 \mu$ .

*Pycnidial stromata* (on twig cultures) tuberculate, spherical, erumpent-superficial and ectostromatic. Stroma light to dark yellow-green and prosenchymatous. Pycnidial locules numerous, irregular to ellipsoid in outline, surrounded by a definite greenish-black pseudoparenchymatous wall which often separates from the surrounding stroma. Locules opening to the exterior through a common ostiole which often forms a papillate swelling on the surface. Conidia numerous, cylindric to allantoid, one-celled, hyaline,  $2.5-3.5 \times 0.8-1 \mu$ , born on simple or branched, cylindric to tapered conidiophores,  $8-11 \times 1-2 \mu$ .

On *Cercis canadensis*, Campus, Athens Ga. April 30, 1934. Collected by J. H. Miller. Type in author's herbarium (No. 3634).

Stromata in superficie comparentia sicut cumuli late erumpentes, nigrescentes saepe confluentes, 2-5 mm. diametro, 1-1.5 mm. crassitudine. Stromatis

superficies ostiolis nigris, productis, asricularibus, fragilibus, saepe tortuosis usque ad 1 mm. longitudine obsessa. Stroma sectum atroviride vel flavoviride intus et ample erumpenti-superficiale. Perithecia parva,  $200\text{--}350 \times 150\text{--}200 \mu$ , polysticha parte stromatis superiori, saepe radialiter producta et cervicibus longis angustis emergentibus sicut ostiola horrida. Asci numerosi, parvi, clavati, non stipitati,  $15\text{--}20 \times 3\text{--}4 \mu$ . Sporae biseriatae minutae, hyalinae, unicellulae, levissime allantoideae vel turgidulae paene ellipsoideaeque.

*Stromata pycnidialia* tuberculata, rotunda, erumpente-superficialia et ecto-stromatica. Stroma pallide vel atro flavo-viride et prosenchymatum. Loculi pycnidiales numerosi, extrema corporum irregulares vel ellipsoidei, pariete haud dubio viridi-nigro parenchymato saepe stromate circumdato disiungenti. Loculi per ostiolum commune saepe tumorem papillosum superficiale formantem dehiscentes. Conidia numerosa, cylindrica vel allantoidea, unicellula, hyalina,  $2.5\text{--}3.5 \times 0.8\text{--}1 \mu$ , conidiophoris simplicibus vel ramosis, cylindricis vel acuminatis,  $8\text{--}11 \times 1\text{--}2 \mu$  sustentata.

#### EUTYPELLA VIRESCENS

A second fungus with olive-green stromata was sent to the writer by J. W. Hotson in 1930, who collected it in Oregon on *Sambucus callicarpa*. Cultures of this fungus were made in 1930 but these were lost before conidial stromata were obtained. On October 10, 1934, sprays of ascospores were again made on a nutrient agar, but no germination took place. The original material was then placed in a damp chamber for several days and ascospores thus matured germinated on October 23 after twenty-four hours on agar. The germinating spores swell enormously and measure  $16.5\text{--}21 \times 3.5\text{--}5 \mu$ . One, or more usually two, germ tubes,  $3\text{--}5 \mu$  in diameter are pushed out from their ends and produce numerous short lateral branches. It is interesting to note that these spores were brought to germination after more than four years under herbarium conditions.

On oatmeal agar, single spore isolations produced a pure white, even, smooth, cottony weft on the surface. Only after some time, and in a few cultures, were small orange colored conidial pustules formed and very few conidia were found on agar.

On November 7, steam sterilized twigs of *Sambucus canadensis* were inoculated from single spore cultures. Here also conidial formation was very slow and infrequent, due in part, apparently, to the very thin bark of this species. On April 16, 1935, inoculations were again made, this time onto sterile twigs of *Ulmus*, *Salix*, *Acer* and *Ribes*. On all these hosts pustules appeared

within two to three weeks. On *Ulmus*, the erumpent stromata produced were white, rather large (1-2 mm. in diameter) and widely scattered. On *Acer*, they were very minute, thickly scattered locally and greenish-yellow, whereas on *Salix* they were

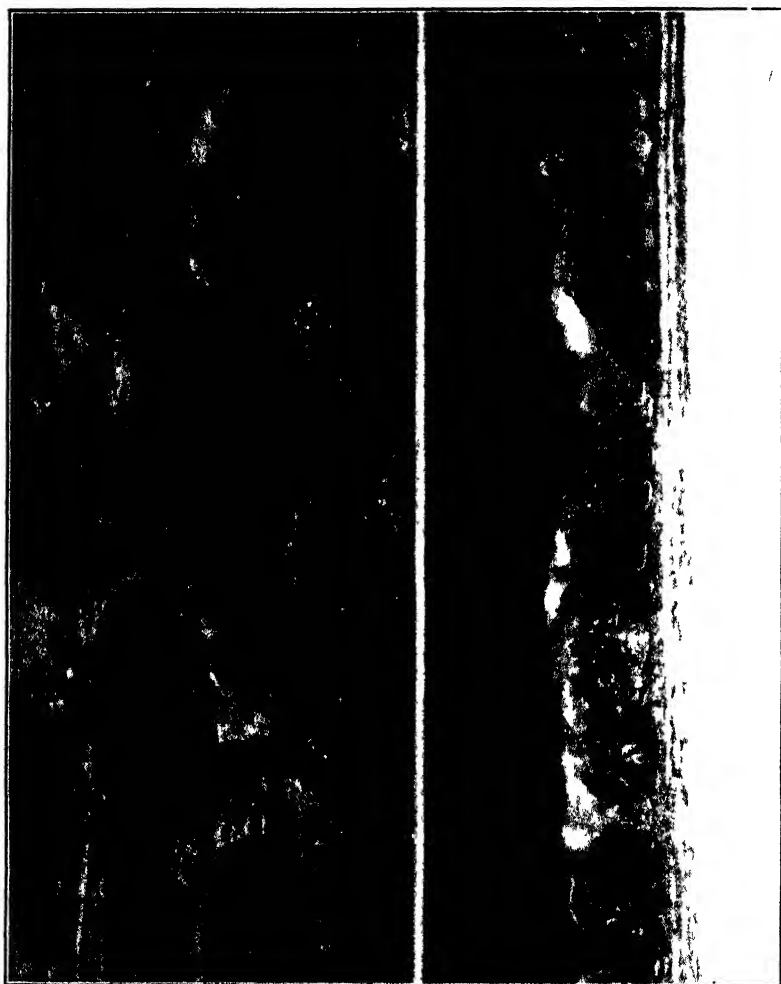


FIG. 2. *Eutypella virescens*: left hand figure, surface view of stromata ( $\times 15$ ); right hand figure, radial section of perithecial stromata ( $\times 15$ ).

intermediate in size, similar in color and thickly scattered over the entire twig. Such variations on different types of bark are of

interest in such a genus with so many host forms and variants of doubtful identity.

On *Salix*, (FIG. 3: 16) there is a more or less effuse formation of hyaline stromatic tissue upon and within the surface layers of the bark cortex. This stromatic layer is increased at certain points to form irregularly spherical masses of stroma within which conidial locules arise, or to give rise to conic stromatic discs which rupture the periderm. The conidial stromata are partially ecto- and partially entostromatic in nature as is characteristic of the genus *Eutypella*. Within these stromata (FIG. 3: 16) there are formed one or several very irregular to labyrinthiform chambers which are lined with a conidial hymenium bearing the long filiform, hyaline, variously curved, one-celled conidia which are  $22-40 \times 1 \mu$ . Neither the cavities nor the stromata have any differentiated wall. Numerous perithecial initials with typical "Woronin hyphae" were seen just beneath or within the base of other sterile stromatic enlargements.

Inasmuch as there appears to be no other similar *Eutypella* with a greenish perithecial stroma so far described, this species is here given as new.

***Eutypella virescens* sp. nov.** (FIG. 2 AND 3: 13-16)

Stromata pulvinate, widely erumpent and strongly pustulate,  $1-2 \times 0.5-1$  mm., often confluent for greater distances. Surface of stroma blackened, rupturing the periderm in a stellate manner by the pressure of growth and containing the scattered, stout, conic, often sulcate ostioles (FIG. 2, left). Interior of stroma bright olive- to yellow-green. Perithecia large,  $600-750 \times 500-600 \mu$ , somewhat radially elongated, crowded in the greenish entostroma, and with short stout necks. Marginal blackened zones faint and irregular when present. Asci (FIG. 3: 13) born in a definite peripheral hymenium, clavate, 8-spored, long stipitate,  $85-100 \mu$  long with stipe, sp. p.  $30-50 \times 5-8 \mu$ . Spores (FIG. 3: 14) yellow-brown in mass, biseriate in the ascus, allantoid, one-celled, yellowish-hyaline,  $6.5-9.5 \times 1-2 \mu$ .

*Pycnidial stromata* (on twig cultures) irregularly ellipsoidal, immersed in the surface layers of the bark cortex. Locules one to several, irregular to labyrinthiform, without differentiated walls, lined with a conidial hymenium. Conidia long filiform, hyaline, one-celled, variously curved,  $22-40 \times 1 \mu$ .



On *Sambucus callicarpa*, Oregon, June 1930, from J. W. Hotson (No. 6). Type in author's herbarium (No. 340).

Stromata pulvinata, late erumpentia et valde pustulata, dense sparsa,  $1-2 \times 0.5-1$  mm., saepe confluentia. Stromatis superficies nigrescens, peridermium adhaerentia stellariter incrementi pressu rumpens et ostiolis valdis, turbinatis saepe sulcatis obsita. Stroma lucidum olivaceum vel flavido-viride intus. Perithecia magna,  $600-750 \times 500-600 \mu$ , rotunda vel elongata aliquando radialiter cervicibus brevibus robustis in entostroma conferta. Zonae marginales nigrescentes obscurae et irregulares si adsunt. Asci in hymenio circumstanti certo clavati, 8-spori, longe stipitati,  $85-100 \mu$  longi (cum stipite), p. sp.  $30-50 \times 5-8 \mu$ . Cumuli sporarum flavo-brunnei; sporae ascum intra biseriatae, allantoideae, unicellulae, flavo-hyalinae,  $6.5-9.5 \times 1-2 \mu$ .

*Stromata pycnidialia* irregulariter ellipsoidea in stratis corticis superficialibus summersa. Loculi complures (vel interdum unus) irregulares vel labarynthiformes, sine parietibus distinctis, hymenio conidiali obsiti. Conidia longe filiformia, hyalina, unicellula, diversiter flexa,  $22-40 \times 1 \mu$ .

#### DIAPORTHE STRUMELLA (Fries) Fuckel var. LONGISPORA

The material upon which this discussion is based was sent to the writer by H. S. Jackson who collected it on *Ribes* at Toronto, Ontario. This material agreed in all respects to *Diaporthe strumella* (Fries) Fuckel except for the fact that the asci and spores were much larger. *Diaporthe strumella* and its conidial stage have previously been reported by the writer (3, p. 178) and will not be discussed here.

This occurrence of apparent varieties of species of *Diaporthe* differing in the elongate ascospores has been noted previously in two distinct cases, once in *D. oncostoma* (Duby) Fuckel (4, p. 142) where elongate ascospores occurred in material matured in a damp chamber and also in a specimen in von Höhnelt's herbarium, and again in a collection of *D. Fagi* Wehm. (4, p. 146), in which case the material was described as a new variety *longispora*.

The spores of the genus *Diaporthe*, and also of many other fungi, are more likely to vary in length than in diameter, and it was probable that these over-sized spores might be the result of more favorable or luxuriant growth. On the other hand, it is equally true that many related species of *Diaporthe* are very similar in many respects except as to spore size. It was of particular interest therefore to culture this long-spored variety and determine whether spore size were constant or merely a variable dependant upon environment.

The spores of typical *D. strumella* (FIG. 3: 12) are  $11-16 \times 2-3.5 \mu$  and the asci are  $37-45 \times 6-9 \mu$ , whereas those found in Jackson's collection (FIG. 3: 8) were  $18-23 \times 3-3.5 \mu$  and  $70-75 \times 7-8 \mu$  respectively. These ascospores when sprayed onto nutrient agar on October 21, 1934, germinated within twenty-four hours by means of, usually, two stout contorted germ tubes some  $5 \mu$  in diameter (FIG. 3: 9). Single spore cultures on oat-meal agar produced a whitish flocculent growth which turned grayish to black with age, due to the formation of blackened dorsal zone on the surface. Numerous pycnidial stromata were formed on the agar surface.

On January 7, 1935, sterilized twigs of *Ribes* were inoculated from single spore cultures. Irregular blackened areas were formed locally on these twigs and in three to four weeks numerous small pustules, which proved to be ectostromatic pycnidia were formed abundantly over the entire infected area. These conic to hemispheric ectostromata originated on the bark surface beneath the periderm and attained a diameter of  $300-800 \mu$  when fully mature. The basal portion penetrated somewhat into the bark cortex, and here there was initiated a flattened locule which became spherical with age and usually developed a definite neck-like opening to the surface, pushing out the numerous conidia in a pale, dull yellowish spore mass or spore horn. These locules possessed a definite wall of olive colored pseudoparenchyma lined within by the hymenium of hyaline filiform conidiophores. In young pycnidia both the alpha and beta type of conidium were present but in older locules only alpha conidia were found. The alpha conidia (FIG. 3: 11) were fusoid to fusoid-cylindric, occasionally tapered toward one end  $9-12 \times 2-3 \mu$ . The beta conidia were long filiform, straight or somewhat curved and  $15-22 \times 1-1.5 \mu$ . Blackened ventral zones were formed deep in the wood or along the margin of the pith, but were present laterally only at the margin of the fruiting areas.

Mixtures of the alpha and beta conidia were sprayed onto nutrient agar and practically all of the alpha conidia had germinated within twenty four hours by means of a single tortuous germ tube,  $3-3.5 \mu$  in diameter, whereas not a single definite case of germination of a beta conidium was seen.

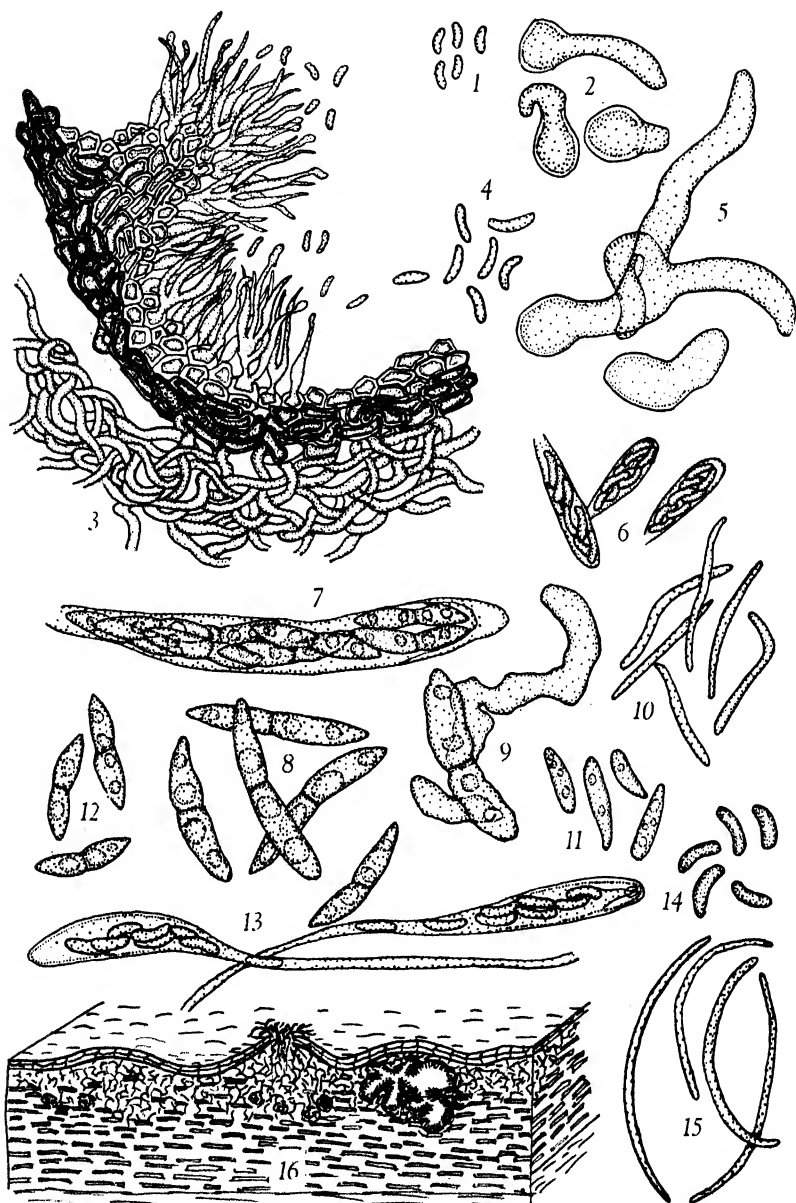


FIG. 3. (Asci and spores  $\times 1000$ ) 1-6, *Endothia viridistroma*: 1, conidia; 2, germinating conidia; 3, radial section through wall and hymenium of prosenchymatous and parenchymatous layers; 4, ascospores; 5, germinating ascospores, showing enormous swelling upon germination; 6, asci; 7-11,

After these cultures had apparently dried out, the twigs were remoistened with sterile water, on March 25. On April 8, perithecia were found beneath some of the sterile ectostromata. Later, by May 1, elongated ostioles, up to 0.5 mm. in length, had pushed through the sterile discs. The perithecia were 300–400  $\mu$  in diameter and clustered in small groups beneath the sterile, conic, yellowish- to greenish-gray ectostroma. The asci (FIG. 3: 7) were  $60\text{--}80 \times 6.5\text{--}8 \mu$ , and the biserial spores (FIG. 3: 8) were long fusoid-ellipsoid, tapered at the ends, straight or more usually curved, constricted at the septum and  $17\text{--}27 \times 3\text{--}4 \mu$ . Spores from the later developed perithecial stromata measured  $15\text{--}23 \times 3\text{--}4 \mu$  and the asci measured  $75 \times 7\text{--}9 \mu$ .

In general structure, both in nature and in culture, therefore, this fungus is practically identical with *Diaporthe strumella*. The size of the ascospores and asci, however, have been distinctly and permanently larger, at least throughout this generation from ascospore to ascospore. It should also be noted that there is a correlated increase in size of both the alpha ( $6\text{--}8 \times 2.5 \mu$  in *D. strumella*) and beta ( $11\text{--}15 \times 1.5 \mu$  in *D. strumella*) conidia over those previously obtained from typical *D. strumella* ascospores. This would indicate that, in this case at least, the greater spore and ascus size is a genetic and not an environmental variation. The cause of such variation is, of course, still obscure. Nevertheless, the fact that such variants do arise within the population of a fungus species and may become fixed indicates one way, at least, in which species differentiation could have taken place in this genus. If the plant under consideration were not so obviously a variant of *D. strumella*, it would most certainly be considered a distinct species. Under the circumstance of this obvious relationship it is here described as a variety of *D. strumella*.

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*Diaporthe strumella* (Fries) Fuckel. var. *longispora*: 7, ascus; 8, ascospores; 9, germinating ascospore; 10, beta conidia; 11, alpha conidia; 12, ascospores of *Diaporthe strumella* (Fries) Fuckel. (compare with those of var. *longispora* in fig. 8); 13–16, *Eutypella virescens*: 13, asci; 14 ascospores; 15, type of conidium found in pycnidial locules; 16, radial section through bark cortex of *Salix* twig representing stromatic development as found in culture on this host; pycnidial locule to right; young perithecial stroma in center.

DIAPORTHE STRUMELLA (Fries) Fuckel var. **longispora** var. nov. (1)  
(FIG. 3: 7-11) \*

Stromatic and perithecial characters as in *Diaporthe strumella* (Fries) Fuckel. Asci clavate, sessile, with a refractive ring in the apex,  $60-80 \times 7-9 \mu$ . Spores biseriate, two-celled, hyaline, fusoid-ellipsoid, usually slightly curved, constricted at the septum, four-guttulate, ends tapered,  $15-27 \times 3-4 \mu$ .

*Pycnidial stromata* as in *D. strumella*. Alpha conidia one-celled, hyaline, fusoid to fusoid-cylindric, sometimes tapered toward one end,  $9-12 \times 2-3 \mu$ . Beta conidia one-celled, hyaline, long filiform, straight or variously curved,  $15-22 \times 1-1.5 \mu$ .

On *Ribes* sp. April 29, 1934, Toronto, Ontario, collected by H. S. Jackson (No. 6083). Type in author's herbarium (No. 3635).

Stromatibus et peritheciiis *D. strumellae* similis. Asci clavati, sessiles apice circulo lucem refringenti,  $60-80 \times 7-9 \mu$ . Sporae biseriatæ, fusoidæ-ellipsoideæ, bicellulæ, hyalinae, rectæ vel paulo curvæ, saepito contractæ, 4-guttulatae, apicibus acuminatis.

*Pycnidiiis* *D. strumellae* similis. A—conidia unicellula, hyalina, fusoidæ vel fusoidæ-cylindrica, aliquando ad apicem unam versus acuminata,  $9-12 \times 2-3 \mu$ . B—conidia unicellula, hyalina, longifiliformia, recta vel diversiter curva,  $15-22 \times 1-1.5 \mu$ .

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# STUDIES OF TWO SPECIES OF ENDOGONE IN CULTURE <sup>1</sup>

BESSIE B. KANOUSE

(WITH 33 FIGURES)

During the summer of 1934, numerous collections of *Endogone sphagnophila* Atk. were obtained on sphagnum in Mud Lake Bog, Whitmore Lake, Michigan, by Dr. Alexander H. Smith. The abundance of fresh material thus made available was an incentive to renew work on the genus *Endogone* in an endeavor to secure the life history of a zygosporo-forming species from culture. Cultures were obtained, and the results from them not only furnished information on that species, but also justified conclusions drawn from a cultural investigation made several years ago on another species of the genus. The results of the earlier study were reported before the Mycological Section of the Botanical Society of America, but were not published. They are included in this paper under the discussion of *Endogone occidentalis* sp. nov.<sup>2</sup> (FIG. 22-32).

The genus *Endogone* is well known from its characteristic zygosporocarpic stage. Due to a lack of sufficient information regarding the sporangial stage, much speculation has arisen relative to its taxonomic position. Bucholtz (3), Atkinson (1), and Thaxter (7) have given in detail the history of the genus and of the various proposed affinities, so that a complete account need not be repeated. Only the considerations upon which the cultural work has a direct bearing will be discussed.

The cultural data presented in this paper extends and clarifies

<sup>1</sup> Papers from the Department of Botany and the Herbarium of the University of Michigan No. 538.

<sup>2</sup> Sporocarpia subglobosa, 2-4 mm., flocculenta, demum squamosa, intus lutea; zygosporae globosae vel ovoideae, 35-47 × 50-60 μ; chlamydosporae globosae, 40-60(100) μ.

In putrido legno. Legit C. H. Kauffman, Lake Quinault, Washington, Oct. 23, 1925. Specimen typicum in Herbario Universitatitatis Michiganensis conservatum.

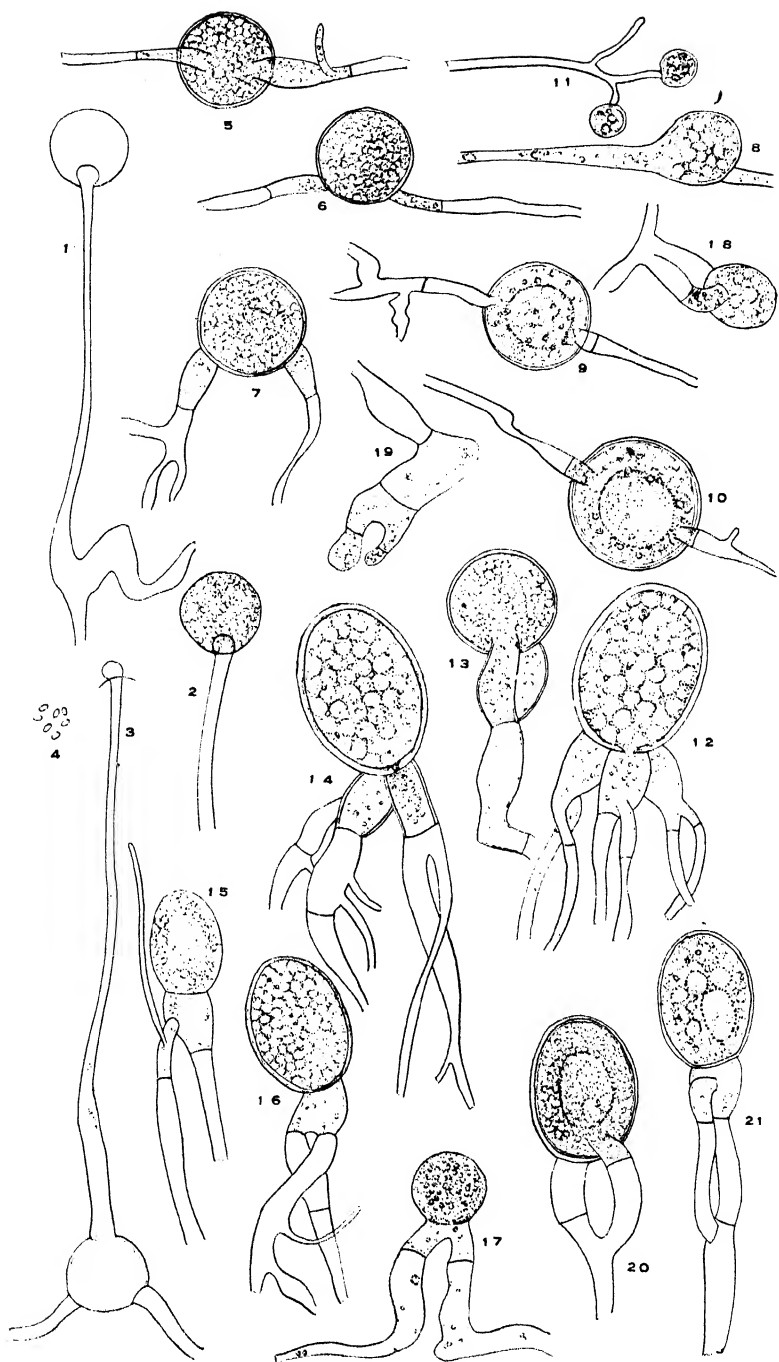
our understanding of the genus *Endogone*; furnishes additional proof for the inclusion of the genus in the Mucorales; and gives weight to the assumption that the Mucoraceae and Endogonaceae are closely related families. Furthermore, the results of the investigation make it expedient to remove two species, *E. malleola* Hark., and *E. reniformis* Berk., from the genus *Endogone* and to place them in a new genus, for which the name *Modicela* is proposed.

Examination of the sporocarps from the sphagnum in Mud Lake Bog showed that they corresponded in all respects to the description of *E. sphagnophila* published by Atkinson (1). His interpretation of the common sphagnum-inhabiting species of *Endogone* has been selected in preference to that of authors who have included this fungus in *E. pisiformis* Link. It is believed that too much emphasis has been placed upon the brief description and simple illustrations published by Link (6) in 1809, and copied by Fries (4) in 1823. Link's illustrations are reproduced in figure 33: 4 accompanying this paper. It is easily understood how such a divergence of interpretation, as is expressed by Buchlotz (3) and by Thaxter (7) could have arisen from the meager information supplied by Link. It is altogether possible that if cultural data were available on fungi that pass under the name of *E. pisiformis*, as it is considered in the broad sense, that distinct differences would be found bearing out the supposition that *E. sphagnophila* is a distinct species. In any event, it seems more logical to refer the cultures upon which this report is based, definitely to *E. sphagnophila* Atk., which concept accurately describes the fungus from which the cultures were derived, rather than to refer them to the inclusive *E. pisiformis*.

#### CULTURAL STUDIES

##### (a) ENDOGONE SPHAGNOPHILA Atk. (FIG.1-21).

Sporocarps were sterilized in a .1 per cent solution of  $\text{HgCl}_2$  and rinsed thoroughly in sterile distilled water as soon as they were brought into the laboratory. Portions of the sporocarps were placed on  $2\frac{1}{2}$  per cent malt agar plates which were placed in a refrigerator registering 12 degrees C. Mycelium developed from two such transfers. The hyphae grew well on synthetic



FIGS. 1-21.



maltose agar, on 1, 2, and 2½ per cent malt agars. The vegetative hyphae formed a compact, flat, growth, grayish-white in color. Under the microscope the mycelium appeared yellowish in color due to the numerous, conspicuous oil droplets contained in the protoplasm. The hyphae measured 3–18  $\mu$  in diameter. Septa were sparingly formed in places other than in connection with the reproductive organs. Sporangia were borne terminally on sporangiophores which arose thickly on the mycelium. The sporangiophores are erect, slender, and unbranched. They reach a height of 250–500  $\mu$ . The sporangia are spherical and measure 18–28  $\mu$  in diameter. (FIG. 1, 2.) The spherical columellae are of a distinctly mucoraceous type and measure 5–8  $\mu$  (FIG. 3). The sporangial wall is fragile and dehisces leaving a small collar at the base (FIG. 3). The sporangiophores are ellipsoid, hyaline, and measure  $2 \times 3.5$ –4  $\mu$  (FIG. 4). With the appearance of sporangia, the cultures assume a soft rosy color, which on the rich malt agar media, is “russett-vinaceous”<sup>3</sup> (R.) to “light russett-vinaceous.” Under the microscope the color of the individual sporangia is bright “English red” (R.). Lendner (5) ascribed the color in the sporangia of *Mucor Romannianus* Moeller as “probablement due a la substance interstisielle.” No definite colored substance was found in the sporangia of *E. sphagnophila* nor could the color be attributed to the spores, although it may have been there or in the sporangial wall. The wall is so quickly diffuent in a water mount that not much can be seen except minute fragments.

Chlamydospores are produced abundantly, accompanying the production of sporangia. They form first in and upon the inoculum where they make a compact layer. Later they are found everywhere except at the margin of the cultures. Often they are as densely packed as are the zygosporangia in a sporocarp, and look remarkably like them when examined under the low power of the microscope. They are usually spherical, rarely ellipsoid or irregular, and measure 30–50–80  $\mu$ ; and they are intercalary (FIG. 5–10). The hyphal attachments are commonly separated by the diameter of the spore, however, some spores were found which seemed to have been formed by a piling up of

<sup>3</sup> Ridgway, R. Color Standards and Color Nomenclature.

the protoplasm against a septum, rather than from an equal flow of protoplasm from two directions. In the latter cases, the hyphal attachments are, then, near to each other on the surface of the spore and as the spore increases in size, gives the appearance shown in figures 5 to 7. The protoplasmic contents of the chlamydospores is at first coarsely granular. Later uniform fatty globules are evenly distributed throughout giving the effect of endospores. Finally a large oil droplet is formed (FIG. 10). The oily contents gives the young chlamydospores a brownish-yellow color, but in old spores the color is intensified so that frequently it is not unlike that seen in zygosporos developed in sporocarps. Mature chlamydospores possess two very thin walls about  $3\ \mu$  in thickness. When broken and treated with chloral-hydrate the wall swells but little. The outer wall is a continuation of the hyphal wall. The inner wall is tardily formed and the two are nearly indistinguishable. The reagent colors the endospore wall "Brazil red" (R.) and the exospore wall blue. The endospore wall makes the separation between the hypha and spore. Septa are found in the hypha, frequently very near the enlarging spore. When the spores regenerate they either send out numerous hyphae or produce a sporangiophore and sporangium as is shown in figure 3.

In addition to the large conspicuous chlamydospores, there are sometimes smaller ones also which measure  $8-10\ \mu$  in diameter. They are spherical and are either terminal or intercalary (FIG. 11).

Zygosporos were obtained in culture. They were produced on mycelium grown on 1 per cent malt agar. The luxuriant vegetative growth made on the high per cents of malt agar indicated that malt was a particularly favorable medium. Hence it seemed desirable to observe further the reactions of the fungus when lesser amounts were employed. Consequently a series of cultures was made in which malt was reduced to 1, 0.75 and 0.5 per cents, together with checks grown on 2 per cent malt agar media. Zygosporos appeared in cultures derived from single sporangiospore isolations, from single chlamydospores and from gross cultures. They appeared only in cultures grown on the 1 per cent malt. While they did not appear regularly in

every culture on this medium, they were present in every one of a series of cultures that was set up and left on the laboratory table from June to November. The zygospores produced in culture were like those formed in sporocarps in both shape and size (FIG. 12-15). They were formed in the manner described for the species by Atkinson (1), whose studies were made on zygospores formed in sporocarps from a bog. The gametangia were conspicuous. However, many of the zygospores formed in culture were atypical in that they possessed several pairs of gametangia. As many as five pairs were sometimes seen connected with one zygospore. Whether or not more than one pair actually functioned in the formation of the zygote could not be ascertained. The size of such zygospores did not differ from that of the typical zygospores, hence there was no reason to suppose that they were the result of multiple fusion. The complicated connections of the zygospores and the several pairs of gametangia were difficult to trace. Some of the typical zygospores and some of the abnormal ones are shown in figures 12-16. The walls of the zygospores did not become as thick nor was the color of the contents as bright in culture as in those formed in sporocarps. When broken and treated with chloriodide of zinc a continuous endospore was seen and the walls then swelled to approximately the thickness of the zygospore walls formed in sporocarps. However, when the oil drop was forced from the zygospore the deep yellow color was easily apparent. What the inhibiting factors were that prevented the zygospores from developing uniformly like those in the sporocarps was not determined. There were indications suggesting that the presence of too much moisture might be a disturbing factor, hence a few trials were made to overcome that situation. The fungus was grown on folded paper pads, the ends of which were immersed in a malt solution, and others were grown on malt agar in a desiccator. Neither set of experiments produced sporocarps.

The production of the zygospores could be correlated more closely with the factor of nutrition. Of the media tried, the 1 per cent malt seemed to provide conditions for the best development of the fungus in all of its phases. As might be expected, the growth of the mycelium and the number of sporangia de-

creased in direct proportion to the amount of malt used. The optimum 1 per cent malt media seemed to allow a good vegetative development and to reduce the nutritional supply to a degree favorable for sexual reproduction. The results illustrate another application of the Klebsian principle which affirms a control of the development of an organism through the nutritional supply. It is impossible to reconstruct in a laboratory the conditions prevailing in a bog. If they could be duplicated with a nicer precision than has been achieved in the attempts just set forth, it is certain that these results could be improved.

It is interesting to note that in habit of growth, and in production of color in the sporangia, *E. sphagnophila* resembles *Mucor Romannianus*. In fact when grown together on 2 per cent malt agar the two species are indistinguishable macroscopically although their hyphae do not mingle. The morphological characters of the sporangia are similar in the two species, but the peculiar chlamydospores and the zygospores of the sort present in the *Endogone* species are not known for the *Mucor*. The chlamydospores of *M. Romannianus* are small, are formed in chains, and are definitely a mucoraceous type. *Mucor Romannianus* var. *angulospora* Maoum. likewise differs from *Endogone sphagnophila*. The spores and color are less like *E. sphagnophila* than are those of *M. Romannianus*.

Another significant feature worthy of mention, since it has such an important bearing on the culture technique, is the freedom from contaminations that one experiences in working with material collected in a sphagnum bog. The usual soil and wood-inhabiting fungi do not seem to be present, so that it is possible to have under observation on agar, for several days, fragments of the mycelium and zygospores, without the usual overgrowth of unwanted fungi.

Attempts to get additional cultures from the sporocarps as they were brought into the laboratory failed. Sporocarps in the initial stages of development were persistently sought but were never found. With but few exceptions mature zygospores only were present. Figures 16-19 show some of the earliest stages observed. That it is not easy to secure the fungus in culture is testified by the fact that innumerable trials have been made

during this and previous seasons by the author without success, and failure has been reported by other investigators also. To what the success of the present report depends is merely a conjecture. Some of the younger sporocarps contained mycelium that was apparently still in an active growing stage, to judge from the dense protoplasmic contents, while in the sporocarps having mature zygospores the mycelium was practically devoid of protoplasm. It is possible that there is a relatively short period in which the active mycelium will respond to the conditions of culture. Probably the presence of such hyphae in a few of the transfers was the source of the cultures not only of *E. sphagnophila* but also of *E. occidentalis* discussed elsewhere in this paper.

Throughout the various studies on the genus, attempts have been made to germinate zygospores. Thaxter, Atkinson and Bucholtz were not able to do so. The author tried the expedient of alternately wetting and drying, of freezing and thawing with no appreciable effects. Some zygospores were left in a tray of a refrigerator for six months; others were kept for three days at a temperature approximating a minus 20 degrees F.; while still others were heated to 60 degrees C., and others were kept moderately warm for periods of many days. Portions of sporocarps were fed to two species of snails and to the common greenhouse slug. The excrement containing zygospores was plated on malt agar. Other zygospores were put directly on the agar media previously mentioned, and also on an agar medium made from sterilized sphagnum. Some were treated with weak acids, others were put in distilled water or in water in which sphagnum was soaked. Most of the spores appeared unchanged by the treatments. Only those that were subjected to the extreme cold disintegrated and appeared dead. The conditions under which they can be made to germinate remains still a mystery, and is one of the intriguing problems in the phycomycetes.

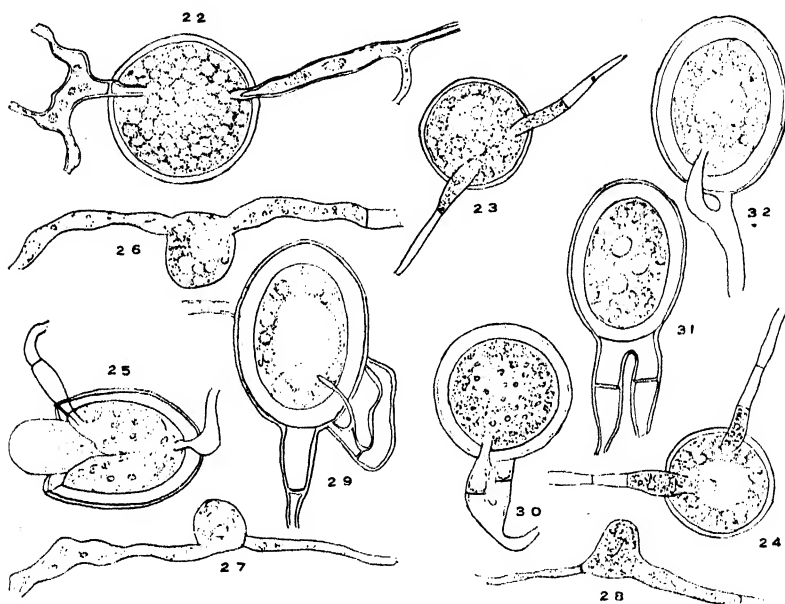
This species, which was studied several years ago, was collected in the autumn of 1925 by Doctor C. H. Kauffman, at Lake Quinault, Washington. The material was received on decayed wood packed in moist sphagnum. No adequate description could be found for the fungus and the name *E. occi-*

*dentalis* is proposed for it. It was cultured as soon as it reached the laboratory at the University of Michigan. The same methods of technique were employed with this fungus that were described for the treatment of *E. sphagnophila*. Successful cultures were derived from a few of the many fragments of mycelium transferred to maltose synthetic agar. When chlamydospores were formed, additional cultures were made from single isolations of them also.

Cornmeal, oatmeal, and 2½ per cent malt and maltose synthetic agars were favorable substrata. The mycelium grew rapidly on the agars and formed a flat, compact, surface growth. Aerial mycelium was infrequent and was found only at the edges of petri dishes and may have been caused by the different atmospheric conditions. The hyphae were thin walled when young. In old cultures many became empty and were very like the vesicular hyphae found in the mature sporocarps. The hyphae were sparingly septate and varied in diameter from 3–18  $\mu$ . Conspicuous oil droplets gave the mycelium a faintly yellowish color. Some of the enlarged segments of the mycelium were filled with protoplasm and remained viable for long periods of time since subcultures were readily obtained from them.

Chlamydospores formed as soon as the mycelium had made a growth measuring a few millimeters. They became densely packed together in the region of the inoculum and also made a compact layer over the surface of the agar. Some were also scattered within it. In a few instances the chlamydospores piled up in such masses that they gave somewhat the appearance of sporocarps, however, no peridial layer and no dense gleba were differentiated, only a loose weft of hyphae developed on which the spores were borne. The chlamydospores were either terminal or intercalary, usually the latter (FIG. 22–27). They were spherical, only occasionally ellipsoid or pyriform. The spherical ones measured 24–60–125  $\mu$  in diameter. They were formed in the same manner as were those described for *E. sphagnophila*. At maturity they possessed two walls, an outer exospore wall which is a continuation of the hyphal wall, and a continuous endospore wall. Together they measure 4–6  $\mu$  in thickness. When stained with chloriodide of zinc the outer wall turned

yellowish in color like the hypha and the inner wall stained "Brazil red" (R.). Young spores stained "Ajuga red" (R.) and within half an hour faded to "dark grayish lavender" (R.) or "Ranier blue" (R.). The action of the stain and the structure of the wall could be observed to the best advantage when the



FIGS. 22-32.

spores were crushed. When this was done, the lamellate structure could be discerned easily. The broken walls always swelled remarkably increasing in thickness to as much as  $12\ \mu$ . (FIG. 25) The endospore swelled more than did the outer wall. The contents of young chlamydospores appeared as homogeneous, coarsely granular protoplasm heavily charged with oil which soon became aggregated into spore-like globules. The oil finally separated out and formed into a large drop or into one large one and several smaller ones. The old spores were colored so deeply orange by the oil that in mass on a slide they were not unlike zygosporcs in appearance. In fact they were so interpreted at first, but the absence of gametangia precludes their being so considered. The presence of two definite walls gives the im-

pression of azygospores. Especially was this effect given by the ellipsoid, terminal spores. However, after a detailed study of hundreds of them the conclusion was reached that probably all were true chlamydospores. The figures published by Thaxter (7) for several species of *Endogone* are very like the chlamydospores that were found in the cultures of the two species studied.

No zygospores were seen in culture. A few hyphae were found which appeared like the very early steps in conjugation but no later stages of development were observed that would confirm that opinion. Figures 26–32 were drawn from sporocarpic material. Sporangia were not found in any of the cultures. The fungus was kept in bacteria-free condition for a period of five years, and during that length of time there was no appreciable change in the cultural characteristics or in the morphological aspects of the fungus. Unfortunately the cultures were lost before interest was renewed through the investigation of *E. sphagnophila*. It is obvious that *E. occidentalis* is less adaptable to culture than was *E. sphagnophila* as it was impossible to obtain the complete cycle of development. The publication of the data on *E. occidentalis* was delayed in the hope of finding sporangia or of germinating the zygospores, by either of which achievements the connection between the cultures and the sporocarps could be strengthened. Neither objective was accomplished. When cultures of *E. sphagnophila* were obtained, the striking similarity of the development of chlamydospores in the two species was at once apparent. Because the results of the investigation on *E. sphagnophila* were so much more complete, yet coincided so perfectly with certain aspects in the development of *E. occidentalis*, a satisfactory interpretation of the earlier study is made possible.

#### DISCUSSION

The most recent taxonomic treatment of the genus *Endogone* is that given by Thaxter (7). He made it clear that the arrangement proposed, was a usable one, though more or less arbitrary, and that as our information concerning the species increased, our notion of the genus would probably be reconstructed. Species included by him in the genus fall into three categories based



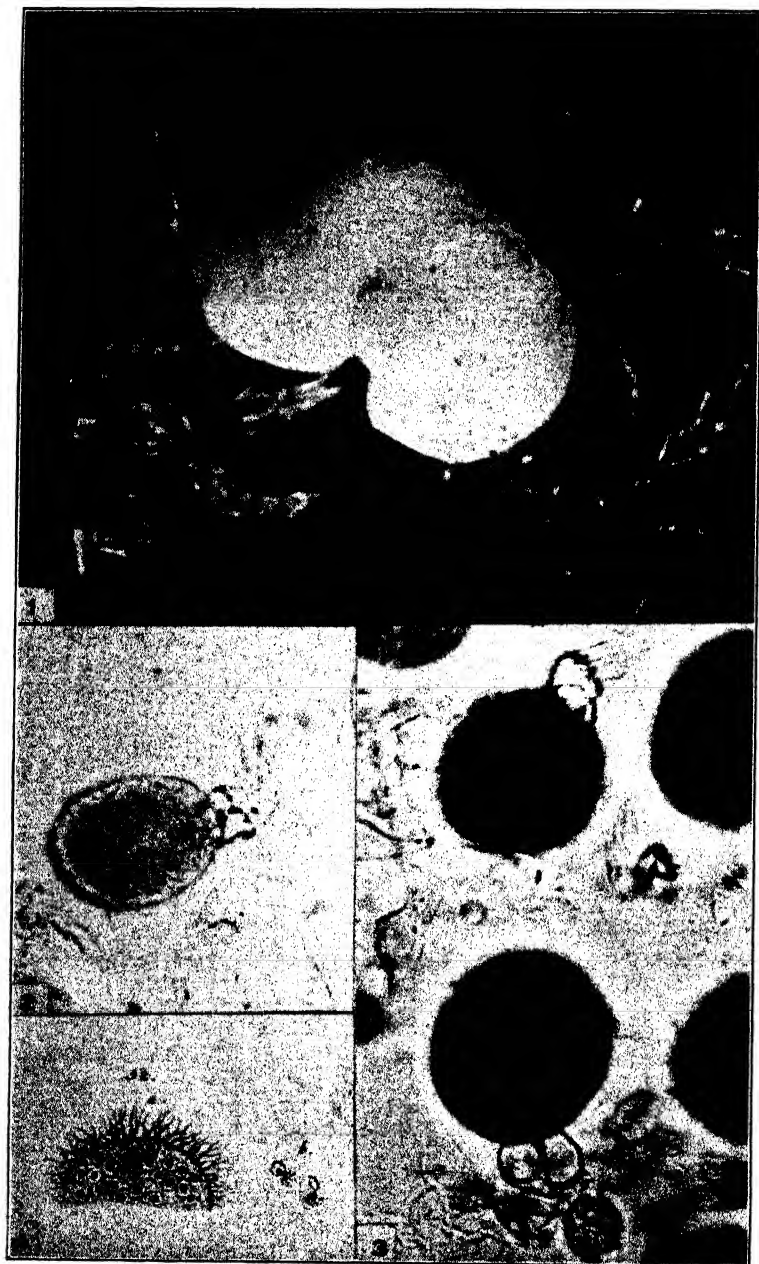


FIG. 33.

upon the type of spore produced. The largest and the best known group is composed of species in which only zygospores are known. A second group comprises species in which chlamydospores alone are found. As Thaxter pointed out, the inclusion of this group in the same genus with the zygospore-forming species "was based entirely on a general resemblance in habit and habitat and similarity in the appearance of the two types of spores." He added substantial evidence for the assumed connection from observations on *E. fasciculata* Thaxter in which species he found zygospores and chlamydospores intimately associated in the same spore mass. Definite proof of the fact that these two spore forms are to be found in the same species is given by the results of the cultural experiments reported in this paper for *E. sphagnophila* and *E. occidentalis*. From these results it is certain that these two groups can no longer be considered separate.

Another category consists of two species, *E. malleola* Hark. and *E. reniformis* Berk. in which only sporangiospores are produced. Again Thaxter stated that in putting them in the genus *Endogone*, he found no evidence beyond the fact "of a certain resemblance between the sporangiocarp in the one case and the sporocarp in the other," which he says "would tend to confirm the correctness of the reference." Baccarini (2) referred these sporangial types to the Mortierellaceae. Bucholtz (3) was unwilling to accept this view based upon the incomplete information available. Thaxter (7) reviewed the evidence for and against such a procedure but retained them in the genus *Endogone*, suggesting that they were as well placed there as elsewhere until we knew more concerning them. Miss Walker (8) who grew *E. malleola* in culture, describes fully the development and pointed out the resemblance between it and characters of the genus *Mortierella*. This likeness is based largely upon the absence of columellae in *Mortierella* species and in *E. malleola*. Since no sexual stage has been reported for either of the sporangiocarpic species, it is impossible to determine with finality the proper disposition of them. Regardless of this difficulty, it is apparent from the data presented here concerning the sporangial stage of *E. sphagnophila* that they should no longer be included in the

genus *Endogone*, in which sporangia of a distinctly mucoraceous type are connected with a zygosporic stage. The lack of columellae and the absence of known sexual stages sets the two species definitely apart from the genus *Endogone*. A new genus *Modicella*<sup>4</sup> is therefore proposed for them. Until more is known concerning the sexual development, it should be placed in the Mortierellaceae.

The position of the genus *Endogone* in the Phycomycetes is already generally accepted by most mycologists. Bucholtz (3), and Atkinson (1) in their studies of the genus have shown that the type of sexual reproduction is similar to that known in the zygomycetes. Bucholtz considered the type of conjugation sufficiently distinct from that known in the established families of the Mucorales, and so proposed the new family Endogonaceae. He recognized the close affinity of this with the Mucoraceae. The presence of the *Mucor*-like sporangia that have been discovered in *E. sphagnophila* confirms this opinion.

The presence of chlamydospores in both species investigated is also of significance. That this type of spore was found so abundantly in culture was not surprising when judged in the light of our understanding of the reactions of other phycomycetes in culture. Throughout this group the formation of exceptionally large numbers of chlamydospores is taken as fair proof of unfavorable cultural conditions. As has been pointed out previously, the conditions maintained in culture were obviously not optimum for the fungus. The fact that in certain species in the genus chlamydospores are the only type known indicates that they are to be expected as representing a significant part of the developmental cycle. It is quite possible that some of these chlamydosporic forms may be found to belong to the zygosporic species already described or not yet discovered. The wall structure in the chlamydospores in these species differs from what is commonly found in other Mucorales. A single wall is the rule elsewhere, while in these two species two walls are found in

<sup>4</sup> **Modicella** gen. nov.

Sporangia globosa, 40–70  $\mu$ , intra miculas intextarum hyphorum; miculae plusminusve stipitatae; columellae deficientes; sporangiosporae numerosae, globosae, hyalinae, 7  $\mu$ ; zygosporae no visae.

Species typicum *Endogone malleola* Hark.

mature chlamydospores. It is not easy to demonstrate their presence in all spores, and the fact that the inner one is frequently very slowly formed only adds to the difficulty. However, in the genus *Glaziella*, in the Endogonaceae, the chlamydospores are described as having two distinct walls, so that it seems that in this family of the Mucorales there is a departure from the usual condition.

*E. sphagnophila* is shown to be a homothallic species from the fact that the complete life cycle was developed from a single sporangiospore, and also from the fact that both suspensors arise from the same hypha as was seen in the young zygosporangia forming in sporocarps on sphagnum (FIG. 20, 21).

Thanks are gratefully acknowledged to Dr. E. B. Mains for helpful criticism and for the photographs.

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#### TECHNICAL DESCRIPTIONS

##### ENDOGONE Link, 1809. Emmended

(Revision adapted from description by Thaxter)

Fructification epigaeous or hypogaeous, producing thick-walled isogamous or heterogamous zygosporangia with or without specialized envelopes; thick-walled asexual non-sexual chlamydospores; sporangia with definite columellae. The zygosporangia and chlamydospores usually produced separately in compact groups; surrounded by a variably developed pseudoperidium or tomentum usually forming a definite sporocarp.

##### ENDOGONE OCCIDENTALIS Kanouse

Fructification sessile, subglobose, flattened, 2–4 mm. in diameter, gleba firm, yellowish, hyphae thin-walled, vesicular, peridium of tightly pressed hyphae forming a tomentum when fresh and appearing as a scaly covering when dry. "Apricot yellow" fading to "pale pinkish buff" when dry; zygosporangia distributed irregularly, broadly ovoid to irregularly spherical,  $35\text{--}47 \times 50\text{--}60$  or  $40\text{--}50 \mu$ , walls  $6\text{--}12 \mu$  thick, lamellate endospore continuous, contents homogeneous, colored bright orange; chlamydospores (in culture) spherical  $40\text{--}60$  ( $100$ )  $\mu$ , intercalary, surrounded by 2 walls.

Type collected on chips and other debris partially buried in

soil at base of very rotten coniferous stump, Lake Quinault, Washington, Oct. 23, 1925 C. H. Kauffman (type); Lake Quinault, Nov. 1925 C. A. Brown, on Douglas fir, Takilma, Ore. Nov. 29, 1925 C. A. Brown. Type deposited in the Herbarium of the University of Michigan.

This species differs from *E. sphagnophila* in habitat, in absence of sporangia in culture, in smaller size and paler color of the sporocarps.

#### EXPLANATION OF PLATE

Fig. 1, sporocarp of *Endogone sphagnophila* Atk. growing on sphagnum; greatly enlarged; 2 and 3, photomicrographs of zygospores taken from a sporocarp; 4, *Endogone pisiformis* Link. Natural size reproduction of the two original illustrations published by Link in 1809.

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# THE AMANITAE OF WASHINGTON

J. W. HOTSON

(WITH 4 FIGURES)

The literature dealing with the Agaricaceae of Washington is rather meager and the field relatively new. In 1922 when Dr. C. H. Kauffman visited this state on a mycological trip he made the remark that "the collector is astonished—nay, somewhat alarmed at his ignorance—to find so many (mushrooms) that appear to be undescribed." During the same visit he made another significant statement that "as a rule the mushrooms of Western Washington and Oregon are Friesian or new," indicating that our forms are more like those found in Sweden than those of eastern United States. Of late years, in the Puget Sound region, considerable interest has centered around edible mushrooms—a condition probably stimulated at least in part, by the present depression and the desire of many people to help to solve the rather serious problem of food supply. Intimately associated with the collection of edible species is the necessity of a knowledge of those forms which are poisonous. Among the latter group none has received more attention than the members of the genus *Amanita*, not only because this genus contains the most deadly of all the mushrooms but also because a number of rather serious cases of mushroom poisoning has resulted locally, from the eating of some of these poisonous forms in mistake for edible ones (2).

The object of this paper is to bring together the various species of the genus *Amanita* that have been reported for Washington. Some few are added which are not as yet reported for this region but have been reported for western Oregon and probably do occur here.

The genus *Amanita* comprises those white-spored forms which have an annulus, a volva, free gills or attached by a line, and a stem readily separable from the pileus. Most of these species are poisonous and are found growing on the ground in woods, in thickets, or under trees in more or less open spaces, sometimes in

fields or on lawns. Since the mycelium is perennial the sporophores or fruit-bodies are likely to be found in the same locality from year to year. In some species the universal veil splits above the pileus and during the enlargement of the fruit-body, slips off leaving the pileus glabrous or nearly so and forming a more or less cup-like volva—the death cup—at the base of the stem, the margin of which extending some distance above the bulb. In other species the universal veil splits by a circular line between the bulb and pileus, leaving remnants on the surface of the pileus as floccose scales, warts, or loose friable patches extending practically over the whole fruit-body. In the following key the first division is made on this characteristic of the volva.

#### KEY TO THE SPECIES OF AMANITA

- A. Volva persistent forming a cup-like structure at the base of the stem, its upper part free from the stem or merely collapsing on it.
  - B. Pileus orange-red or yellow.
    - C. Pileus orange-red to orange-yellow, 8–20 cm. broad.
      - 1. *A. caesarea* Fries
    - CC. Pileus without orange or red shades.
      - D. Spores globose or sub-globose; pileus honey-yellow or straw-colored, umbonate, the umbo yellowish becoming umbrinous.....2. *A. umbrinidisca* Murr.
      - DD. Spores elliptical.
        - E. Pileus yellowish or yellowish-brown, tinged with green.
          - 3. *A. calyptrola* Peck
        - EE. Pileus not tinged green.
          - 4. *A. calyptroderma* Atk. & Ball
    - BB. Pileus not orange nor yellow.
      - F. Pileus pure white, margin of the pileus even.
        - G. Pileus conical when young; annulus rarely formed.
          - 5. *A. virosa* Fries
        - GG. Pileus convex then expanded; annulus normal.
          - 5. *A. verna* Fries
      - FF. Pileus brown or grayish-brown.
        - H. Margin striate.....4. *A. calyptroderma* Atk. & Ball
        - HH. Margin not striate; pileus viscid, glabrous or with a few remnants of scales.....5. *A. phalloides* Fries
  - AA. Volva splitting in a circular line between the bulb and pileus (circumscissile) and forming an abrupt inrolled sheath or several imperfect rings.
    - I. Pileus yellowish, sometimes orange or orange-red.
      - J. Pileus striate.
        - K. Pileus 8–20 cm. broad usually orange or orange-red; sometimes lemon-yellow; bulb with concentric scales or rings.
          - 6. *A. muscaria* Fries

- KK. Pileus 3-11 cm. broad; bulb without concentric scales or rings.
- L. Spores globose 8-9  $\mu$  in diam.; pileus 3-8 cm. broad, usually white, sometimes slightly tinted yellow or tawny-olive at the center. . . . . 7. *A. cothurnata* Atk.
- LL. Spores elliptical 10-12  $\times$  7-8  $\mu$ ; pileus pale-yellow 5-11 cm. broad. . . . . 8. *A. junquillea* Quél.
- JJ. Pileus not striate.
- M. Bulb conspicuously marginate-depressed, 2-3 cm. broad; pileus 4-8 cm. broad. . . . . 14. *A. Mappa* Fries
- MM. Bulb rounded, not marginate-depressed.
- N. Pileus 8-20 cm. broad. . . . . 6. *A. muscaria* Fries
- NN. Pileus up to 6 cm. broad. . . . . 9. *A. praegemmata* Murr.
- II. Pileus not yellow nor yellowish.
- O. Base of the stem more or less deeply rooted.
- P. Odor strong of chlorine or chloride of lime. . . . . 10. *A. chlorinosma* Peck
- PP. Odor not strong of chlorine or chloride of lime. . . . . 11. *A. solitaria* Fries
- OO. Base of stem rounded, not root-like.
- Q. Pileus white or whitish.
- R. Margin of the pileus finely striate when mature, sometimes darker at the center. . . . . 7. *A. cothurnata* Atk.
- RR. Margin of the pileus not striate, persistently incurved; the whole plant pure white. . . . . 12. *A. silvicola* Kauff.
- QQ. Pileus gray, brownish-gray or smoky-brown.
- S. Spores globose 8-9  $\mu$ ; bulb marginate-depressed; margin of the pileus even.
- T. Annulus median or inferior; cap and stem covered by an ashy-colored pulverulence. . . . . 13. *A. tomentella* Kromb.
- TT. Annulus superior. . . . . 14. *A. Mappa* Fries
- SS. Spores elliptical 10-12  $\times$  7-9  $\mu$ ; margin of pileus obscurely striate; bulb subspherical. . . . . 15. *A. pantherina* Fries

## 1. AMANITA CAESAREA Fries

This beautiful, large, orange-red mushroom which is one of the most attractive of the whole group has rarely been found in Washington. It has been collected on two different occasions in the Black Hills, west of Olympia. It is readily recognized by the large size and bright color of the pileus which is striate and glabrous at maturity and also by the prominent, white, sac-like volva. Even in the button stage it is easily distinguished by its close resemblance in size, shape, and color to a hen's egg. It is not poisonous.



2. *AMANITA UMBRINIDISCA* Murr.

Syn. *Venenarius umbrinidiscus* Murr.

The type specimen of this species was collected by Murrill in the fall of 1911 in a fir forest near Seattle (7). The yellowish umbo becoming umbrinous at maturity, the conspicuous long-striate margin, and the large subglobose spores (7–9  $\mu$ ) are the most striking characteristics.

3. *AMANITA CALYPTRATA* Peck

The type specimen of *A. calyptrata* was collected in Oregon in 1900. It has also been found in the vicinity of Seattle under Douglas fir. It can be readily recognized by the large size of the pileus (10–20 cm. broad), the greenish tinge that pervades the whole fruit-body, and "by the large persistent patch of grayish-white felty material that covers the center of the pileus and sometimes extends nearly to the margin." It is not poisonous.

4. *AMANITA CALYPTRODERMA* Atk. & Ball.

Syn. *Amanita calyptratoides* Peck (10)

This species has been collected in the vicinity of Seattle but is apparently rather rare in Washington. It is however, more common in Oregon where it has been collected by Kauffman (6) in the Siskiyou Mountains and by Zeller (10) in the woods near Corvallis. As the name implies, this species resembles closely *A. calyptrata* Peck. It differs, however, in the absence of the greenish tint in the pileus, gills, and stem, also in the presence of striae on the upper part of the stem, and in the thick double volva at the base.

5. *AMANITA PHALLOIDES* Fries

In this state, *Amanita phalloides* has been found only a few times. It has been collected in the vicinity of Olympia, Centralia, and in the Cascade and Olympic mountains by Mrs. Maude E. Morris. All of these specimens were of the umber-brown to smoky-olive type with the margin of the volva free and torn—not circumscissile. The brownish stems have a polished appearance when young, but break up and become roughened in age. As a rule our plants are not as large as the described type, being about 6–8 cm. broad with slender stems.

Closely related to *A. phalloides* are *A. verna* and *A. virosa*, all three apparently containing the same poisonous activating principle. They are all about the same size, with the pileus viscid, the margin even, the gills free or adnexed by a line, and the spores apiculate. The spores, however, are slightly smaller in *A. virosa*. The sporophores of the latter are more or less conical when young, while those of the other two are convex becoming expanded. The pileus and the stem of both *A. verna* and *A. virosa* are pure white while in *A. phalloides* the pileus is umber-brown or smoky-olive. At times, however, the margin in the latter becomes whitish but never pure white. The annulus of *A. phalloides* is similar to that of *A. verna* but in *A. virosa* it is evanescent. The writer has found neither of the last two in Washington.

#### 6. AMANITA MUSCARIA Fries (FIG. 1)

The bright-scarlet pileus, spotted with white patches makes *A. muscaria* a fair rival of *A. caesarea* for first place among our mushrooms for beauty and attractiveness. It is widely distributed throughout the Puget Sound region in various types of soil and under both coniferous and deciduous trees. It has been collected in and around Seattle, Tacoma, Olympia, Kirkland, Summit, Grays Harbor and on Bainbridge Island.

Besides the bright-scarlet European type there is a form resembling that found in eastern United States. This is a handsome-looking mushroom with lemon-yellow to pale-yellow pileus bedecked with white or yellowish-white scales. Up to the time Dr. Jakob E. Lange of Denmark visited the Pacific Coast on a mycological trip in 1931 this form was considered the *formosa* variety of the European species. A recent letter from Dr. S. M. Zeller who was in close touch with Dr. Lange while here, says in part, "Dr. Lange believes it (the lemon-yellow variety of *A. muscaria* found along the Pacific Coast) is different from anything in Europe including the named varieties. Until he made this statement I was hoping that we could use the name *A. formosa* and raise it to specific rank, but I think Dr. Lange knows the European forms well enough to take his word for it." Both Dr. Lange and Dr. Zeller are inclined to consider our yellow form

as a new species and identical with the form commonly found in the eastern United States. More careful study, however, is necessary before coming to a definite decision on this point.

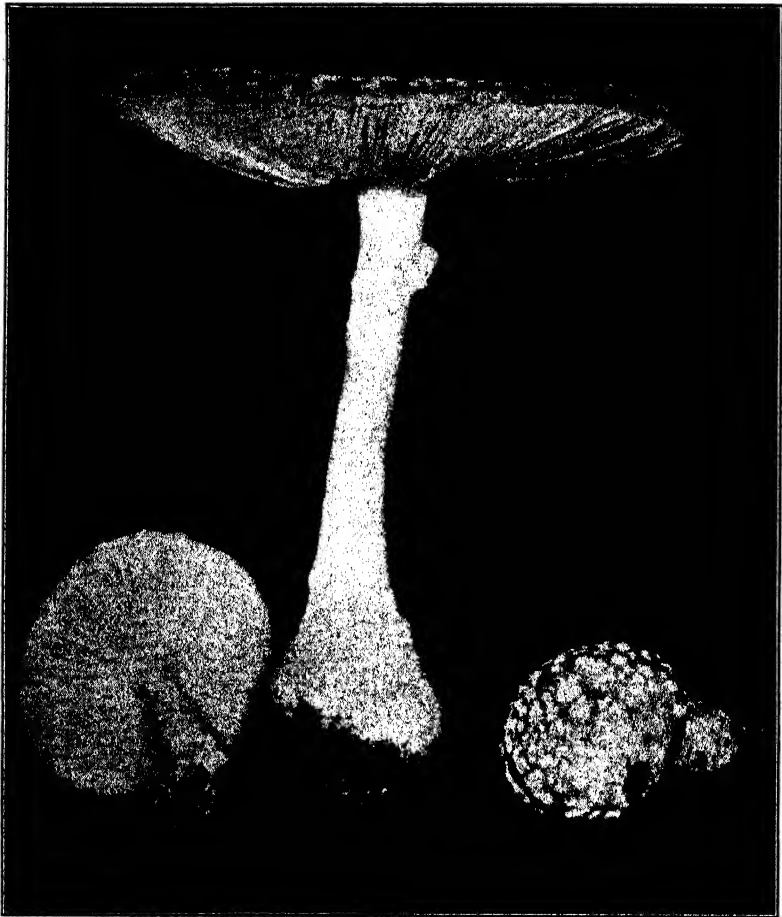


FIG. 1. The lemon-yellow variety of *A. muscaria*.

Another variety, *umbrina* has a brown or umber-colored pileus, approaching *A. pantherina* in general appearance, but it may be distinguished by its yellowish stem which is most pronounced above the annulus. It has been collected along Denny Creek near Snoqualmie Pass.



FIG. 2. A, *Amanita junquillea*; B, *Amanita chlorionosma* showing the dense white floccose structure of the veil; photo by C. F. Todd.

7. *AMANITA COTHURNATA* Atk.

This species has been reported from the vicinity of Seattle, Bremerton, and Keyport but rather infrequently. Like many other *Amanitas* the color of the pileus varies considerably. When pure white, it is readily distinguished by the finely striate margin of the pileus, but sometimes the center is tinged yellow or even tawny-olive in which case it might be confused with *A. pantherina*. It may be distinguished from the latter, however, by the character of the spores which are smaller and globose ( $8-9\ \mu$  in diameter). Some interesting specimens of the pale-yellow type with brownish-tinted centers resembling the light-colored forms of *A. pantherina* have been collected by Mrs. Maude E. Morris. The gills of these specimens are definitely serrulate. For illustrations of the gills, the upper surface of the pileus, and the volva see Ref. 7.

8. *AMANITA JUNQUILLEA* Quél. (FIG. 2A)

In Washington *Amanita junquillea* has been collected on the University campus, Fort Lawton, in the Cascade Mountains near Summit, and quite abundantly on the open "prairies" around Olympia where the soil is composed of black silt and humus. Kauffman (5) reported this species from Mt. Hood, Oregon, in 1922. Our western species follows quite closely the description of the European form as given by Ricken (9), the spores measuring  $10-12 \times 7-8\ \mu$ .

This species may be recognized by the pale yellow-buff pileus (5-9 cm. broad), covered with white patches of the universal veil, the striate margin which exceeds the gills, and the size of the spores.

9. *AMANITA PRAEGEMMATA* Murr.

Syn. *Venenarius prae-gem-matus* Murr.

The type specimen of *A. prae-gem-mata* was collected by Murrill in 1911 "on sandy soil in open woods near Seattle." It was also collected at Coos Bay, Oregon. Murrill states that "fresh specimens suggest one of the honey-colored forms of *A. muscaria* and the dried specimens are not very different from small plants of *A. rubescens*." This species has not been found by the writer.

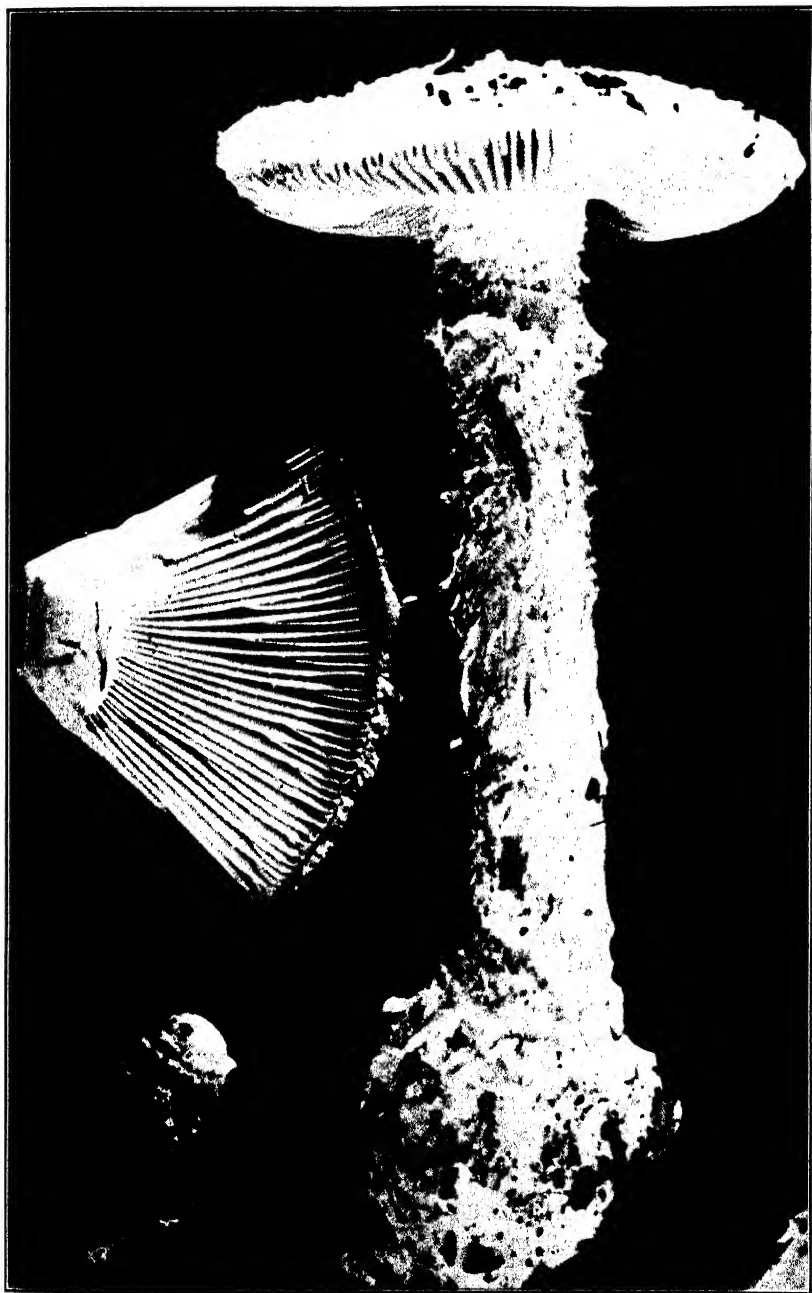


FIG. 3. *Amanita solitaria*.

10. *AMANITA CHLORINOSMA* Peck (FIG. 2B)

This species has been collected in the vicinity of Seattle and Olympia. When once found one can nearly always depend on finding it in the same locality for several seasons. When growing in deep, dark woods where the sun does not penetrate, our plants fit rather closely the description given by Kauffman (4 p. 615). In open woods on gravelly soil like that east of Olympia, the specimens might easily be mistaken for *A. solitaria* as the pileus then is grayish-brown with harder, more warty scales.

Since *A. chlorinosma* is so variable, many authors have had difficulty in distinguishing it from *A. solitaria* and *A. strobiliformis*. Until some of these discrepancies are cleared up by further study, it would seem best to follow Kauffman's suggestion (4 p. 616) and refer all out forms, which have a strong penetrating odor of chlorine or chloride of lime, to the species *A. chlorinosma*.

11. *AMANITA SOLITARIA* Fries (FIG. 3)

*Amanita strobiliformis* Vitt.

In western Washington *A. solitaria* has been found rather infrequently around Seattle, Edmonds, Steilacoom, and Duvall, in deep coniferous woods. Sometimes after hard, prolonged rains, all the volva patches wash off leaving the pileus smooth. The pileus then feels like wet kid leather. The gills of our plants are minutely crenulate on the edge as shown in figure 3. This is in accord with the description given by Rea for the European species but Kauffman describes them as "even" while Atkinson states that "the edges are often floccose where they are torn from the slight union with the upper surface of the veil." Because of the great variation in this species, some authors, including Kauffman, Bresadola and Atkinson, (4 p. 615) consider *A. solitaria* and *A. strobiliformis* as identical assuming that the variations occurring in the scales on the pileus and stem and in the shape of the bulb and stem, are not sufficient to warrant forming two species. The writer is inclined to accept this interpretation until further investigation demonstrates that a different view is preferable.

## 12. AMANITA SILVICOLA Kauff.

The pileus of *A. silvicola* is 6-12 cm. broad, pure white, floccose but not forming firm warts, and not striate, the gills are free or decurrent by a line, sometimes approaching an adnate condition. There is no odor or taste. The spores are elliptical, smooth, obliquely apiculate, measuring  $9-10 \times 5-5.5 \mu$ . The type specimen was collected by Kauffman on Mt. Hood, Oregon in 1922 (5). In Washington it has been found quite frequently in the fall along road-sides or in coniferous woods. It has been collected on the "prairies" around Olympia and Tacoma, as well as in the vicinity of Seattle, Kirkland, Edmonds, Everett, Stevens Pass, and Grays Harbor. When growing on the "prairies" where there is considerable black silt in the soil, it is almost dark-gray in color due to the fine dark silt adhering to the fluffy pileus. This locality seems to be especially well suited for its growth for it is found abundantly and often in dense clusters of five or six in a group. Occasionally one will be found with a root-like extension somewhat similar to *A. solitaria*. In extreme age the pileus of *A. silvicola* develops bright rose-colored spots and streaks, the beginning of decay. It resembles *A. chlorinosma*, *A. cothurnata*, and *A. solitaria* in having a pure white sporophore and a loose-fitting sheath-like volva. Of these species the first may be easily distinguished by its characteristic penetrating odor of chlorine or chloride of lime; the second by the striate margin of the pileus; and the third by its rooting bulb, the firm warty scales on the pileus, the broader spores, and the character of the universal veil.

## 13. AMANITA TOMENTELLA Kromb.

Kauffman (5) collected this species on Mt. Hood, Oregon, in the autumn of 1922 in a hemlock and cedar forest. The writer has not found it in Washington but it probably is here. Kauffman referring to this species (4 p. 607) says: "It is easily known by the ashy-colored pulverulence on cap and stem, and the median, pendant annulus. The main color of the pileus varies from umber-brown to drab, with an obscure tinge of lilac, or purplish." The margin of the pileus is not striate.



## 14. AMANITA MAPPA Fries (FIG. 4)

The smoky or grayish type of *A. Mappa* as described by Kauffman (4 p. 609) is quite common in the vicinity of Seattle. Although usually solitary, sometimes six or eight specimens may occur fairly close together in a single group. It apparently obtains a maximum development in moderately dry, well-shaded, second-growth stands of conifers. The pileus is silky, grayish or grayish-brown bearing a few rather large, irregular, floccose, whitish patches on the top. The circumssissile volva and the large spherical, marginate-depressed bulb are usually sufficient to distinguish this species from closely related forms such as *A. phalloides*. These facts, however, are not sufficient to distinguish it from *A. tomentella* as described by Kauffman. The size of the pileus, the shape and size of the spores are practically the same in both species. The main differences between them seem to be the lilac or purplish tinge of the pileus in *A. tomentella*, and the position of the annulus which is superior in *A. Mappa* and median or inferior in *A. tomentella*. Although the annulus of *A. Mappa* is usually superior as illustrated by Atkinson (Fig. 58, p. 58 "Mushrooms," under *A. phalloides*), yet not infrequently, as is shown in Fig. 4 of this article, it is nearly median. This fact is also brought out by the illustrations of this species by Brasodola (Vol. 1, Tab. 7) and by Ricken (Taf. 77: Fig. 2). Some authors consider the smoky or grayish type of *A. Mappa* as a variety of *A. phalloides* just as *A. tomentella* is regarded as a variety of *A. porphyria*. There are several points in which these closely related forms need further investigation especially in the field. It is possible that a different disposition of this type of *A. Mappa* and *A. tomentella* may be desirable when additional information is obtained.

## 15. AMANITA PANTHERINA Fries

*Syn. Amanita pantherinoides* Murr.

Of late years not a little confusion has arisen over the relation of *A. pantherina* Fries to *A. pantherinoides* Murr. In a previous paper (3) these two species have been shown to be identical hence *A. pantherinoides* is here considered as a synonym.

This species is widely distributed over western Washington having been collected at Anacortes, Seattle, Tacoma, Fort Lewis, Mt. Rainier, Nisqually Valley, and Grays Harbor. Zeller reports it from Corvallis, Oregon. It has been found most abundantly



FIG. 4. *Amanita Mappa*.

on the Tacoma "prairies" and around Fort Lewis under young Douglas fir trees. Often the collections made in the spring and in the fall were from under the same tree. It has been shown to be poisonous (2). Many cases of mushroom poisoning have been reported both in the spring and in the fall.

The color of the pileus of *A. pantherina* varies considerably. Besides the typical brownish or cinnamon-brown form, yellowish or yellowish-brown variations occur. These light-colored specimens resemble closely similar forms of *A. cothurnata* and the two might be easily confused, the chief distinction being the size of the spores. To add to this confusion the writer has found, as

Beardslee has (1), that in dried specimens, especially if they have been dried rapidly, the outside wall of some spores break away so that the large spherical globule, so conspicuous in the fresh material, is seen free, and often swells somewhat in the water. These structures when examined, would readily fit the description of the spores given for *A. cothurnata* namely, "globose, 8-9  $\mu$  in diameter." Further work is contemplated on the relationship of these two species whenever material is available.

The writer is indebted to Mrs. Maude E. Morris for valuable suggestions in connection with the preparation of this paper, and also to Mr. C. F. Todd for the photograph of Figure 2B and to Mr. D. E. Stuntz for several of the other photographs.

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# SPORANGIA OF A PHYCOMYCETE IN VESSELS OF PHILODENDRON RIGIDIFOLIUM

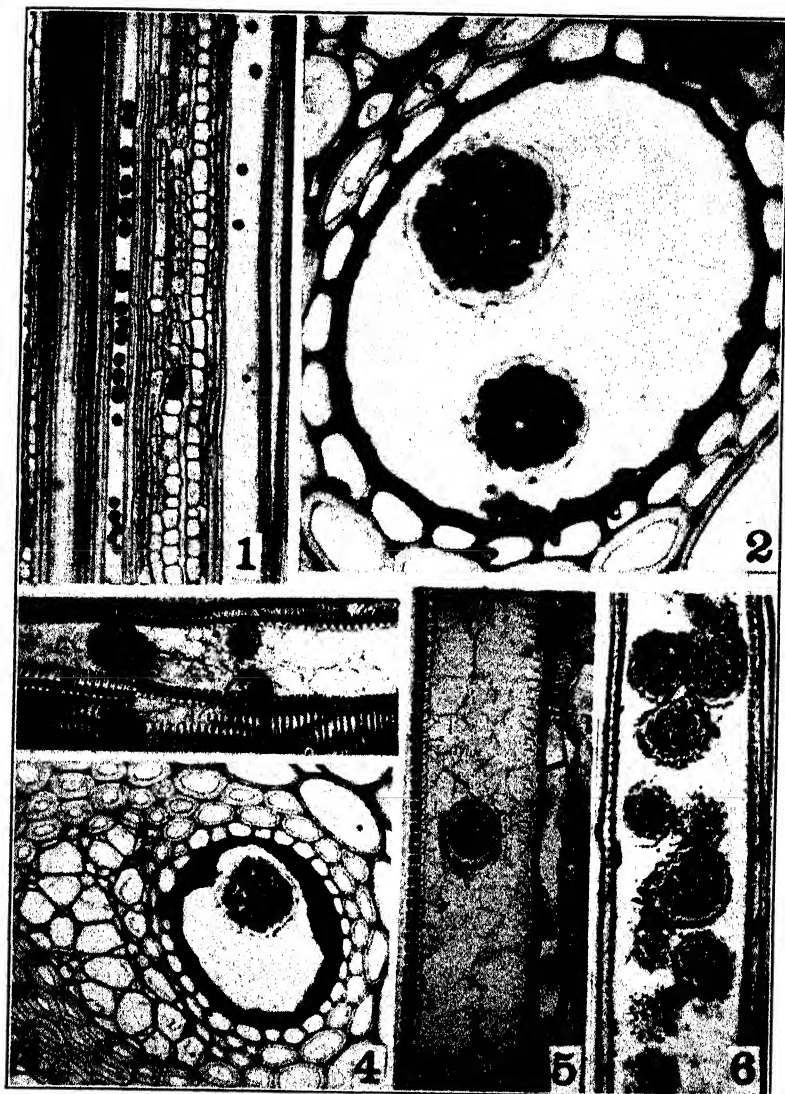
ROBERT H. WOODWORTH

(WITH 6 FIGURES)

*Philodendron rigidifolium* Krause is a creeping epiphytic aroid. It is endemic being known only from the vicinity of the Canal Zone. Locally it is called "cinchadora" probably because of some astringent principle or possibly because of its skunk-like odor. Its leaves are applied as poultices to snake bites. The plant bears several non-peltate, imperforate, entire, broadly ovate leaves with winged petioles. The flowers are monoecious, the pistillate being on the lower part of the spadix, the staminate above and with separate stamens. The specimens discussed in this paper were collected on Barro Colorado Island by R. H. Wetmore and the writer in July 1929.

The internal anatomy is of the monocotyledonous type. The stem is densely packed with vascular bundles each containing a large solitary vessel of about 1.3 mm. diameter, and about 16 sieve tubes (FIG. 4). The bundles are sheathed by sclerenchymatous tissue. While making a routine examination of the internal morphology of many tropical plants, peculiar structures were noted in the vessels. Subsequent examination of carefully prepared sections of this stem showed the bodies in question to be sporangia of some fungus. As they are in the vessels, longitudinal sections show their distribution to best advantage. Figure 1 shows a number of sporangia in one of the smaller vessels and a few scattered sporangia in a larger vessel to the right. Occasional vessels are heavily infested, others have only a few sporangia, while still others have none.

Figure 2 shows a cross section of a vessel with two of the sporangia in the lumen. The wall of the sporangium has some appreciable thickness and the spores with their nuclei are readily seen. Some of the vessels contain deposits of gum-like substance



FIGS. 1-6. Photomicrographs of sections of stem of *Philodendron rigidifolium*. 1, longitudinal section showing sporangia in vessels,  $\times 60$ ; 2, cross section showing two sporangia within a vessel (nuclei of the spores can be seen,  $\times 750$ ); 3, longitudinal section showing dense hyphae and several sporangia within the vessels,  $\times 130$ ; 4, cross section of a vessel containing peripheral deposit of dark staining substance and a sporangium,  $\times 290$ ; 5, longitudinal section of vessel with one sporangium and network of hyphae,  $\times 180$ ; 6, longitudinal section of vessel packed with sporangia several of which have broken open,  $\times 200$ .

as in figure 4. This was apparently present in the vessels before infection because in several cases where the vessels were occluded by it sporangia were formed adjacent to the occluding masses, but none were seen within this material.

In most sections from preserved specimens of this stem the hyphae are diffuse and not easily studied because of their small size. In some few cases hyphae are in great abundance as in figures 3 and 5. Since it is not possible in photomicrography to obtain any considerable depth of focus the density of the hyphal mass is not recorded. The fungal threads pass through the pits in the vessel walls, ramify through the lignified cells of the bundle sheath and penetrate the parenchyma cells of the fundamental tissue. No hyphae have been seen in the phloem cells. Apparently sporangia form only in the vessels. In some cases the sporangia may be almost large enough to occlude the vessel (FIG. 3); more often they have a diameter of from one-quarter to one-half that of the vessel. The spores measure  $3 \times 4$  microns. Small sporangia contain a dozen or more spores while large ones form several hundreds.

The question early arose as to whether the fungus was in the plant when it was collected or whether it might possibly have penetrated the plant tissues after collection. Representative parts for herbarium specimens and for anatomical study were selected from plants which appeared to be quite normal and healthy. The stems were cut into one foot lengths, tied together and numbered. Collections were made in the morning and were worked over in the afternoon. Material for preservation therefore rested from two to six hours before being cut into small cubes, tied in cheese cloth bags and placed in a 1 per cent chromo-acetic acid solution where it remained for twenty-four hours. After this it was washed in water for twenty-four hours, then placed in form-alcohol (5 per cent formalin, 50 per cent ethyl alcohol) where it remained for some months. Specimens for herbarium sheets were treated in the usual manner and the presses placed in a drying closet containing oil heaters. Naphthalene flakes were sprinkled on the dry plants before bundling. The fungous sporangia under discussion are found not only in the preserved material but also in the dried herbarium specimens.

It does not seem, even in the warm and humid atmosphere of Panama, that a fungus could possibly grow fast enough to penetrate the whole stem and then form large numbers of sporangia in the few hours between collection and preservation. Among hundreds of specimens of other plant species nothing similar to this has been seen even in other species of the genus *Philodendron*. It appears to be a reasonable assumption that this organism is a parasitic fungus.

The relationship between host and parasite should receive further study in order to determine its full biological significance. In this connection attention is called to the epiphytic habit of the host. Parasitic fungi are commonly in soil and they enter plants through the root system. This host has no roots in the soil. It is possible that the fungous spores are carried by some insect as is the case with many well known pathogenic fungi. Such a spore carrying insect while feeding on the plant or sucking its juices could cause inoculation. The formation of the fungous sporangia within the vessels, and of course therefore in water, suggests a means of rapid spread through the plant. If the sporangia break open within the plant the spores could easily be carried about by the transpiration stream thus spreading the parasitic organism much faster than it could grow. Figure 6 shows eleven sporangia four of which appear to have released their spores. Many similar cases have been observed. Sporangia are occasionally cut open by the microtome knife but when this has occurred the spores all float away during the process of slide making. In those sporangia which seem to have been naturally broken the mass was imbedded by the celloidin. Possibly the sporangia do not break and release spores until the plant decomposes.

Attempts to cause the germination and growth of the spores from stems of herbarium specimens have proved unsuccessful. This is not surprising because parasitic fungi of this type are notoriously difficult to culture. Furthermore the spores have been desiccated and subjected to continuous naphthalene vapors for over five years.

Because no living material is available it is not possible to place this fungus in its proper taxonomic group with any degree of certainty. The characters of the hyphae, for instance, in the

killed and fixed material may be quite unlike those of the living organism. Several competent mycologists have suggested that the fungus may be a member of the filamentous Chytridiales or the Mucoraceae. If the former it is an unusual species in that the host is a vascular plant. It is hoped that this report will focus attention on what appears to be a most interesting organism.

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## A NEW IMPERFECT FUNGUS

A. G. PLAKIDAS AND C. W. EDGERTON

(WITH 1 FIGURE)

While making a study of the organisms associated with a root and collar rot of pear trees in Louisiana, a fungus with very characteristic spores was isolated from the dead bark. This fungus apparently does not fit in any of the described genera of fungi and consequently a new genus is erected for it.

The outstanding peculiarity of this fungus is the form of the conidia. These are wedge-shaped with very deep constrictions and resemble the common illustrations of Christmas trees (FIG. 1, *A, B, C, D*). The conidia are hyaline and two-celled. When viewed from the edge, they are seen to be flattened to slightly convex on one side and flattened to slightly concave on the other. The septum occurs just above the basal lobes. The conidium is borne on a slender stalk and when detached, approximately one-half of the stalk remains attached to the spore as a pedicel, while the other half remains on the conidiophore as a sterigma (FIG. 1 *C*).

The conidiophores arise as branches of hyphae and are at first short and somewhat thickened, but later elongate and become of approximately the same thickness as the mycelial threads. They are hyaline, septate, often branched and very variable in length. Each conidiophore, or its branch, bears a variable number of conidia (1-6 noted). A conidium starts to develop near the apex of the conidiophore, but it is pushed aside as the latter continues to grow and becomes lateral. The youngest spores consequently are those nearest the apex of the conidiophore.

In pure cultures, the young mycelial threads are hyaline, septate, creeping and closely appressed to the agar surface. The older threads thicken and become closely septate and brown in color, giving the cells a chlamydospore-like appearance. On still older cultures, the aerial growth may almost disappear and the

surface of the colony becomes dark and leathery. The conidia germinate readily and the fungus makes a satisfactory, though rather slow growth, on a variety of media. In a number of tests at room temperature, the average diameter of 8-day colonies was 17.6 mm. on beanpod agar, 20.00 mm. on dextrose agar, and 25.2 on Czapek's agar. The fungus sporulates very profusely on all the media tried, the spores usually beginning to form after about two days. In older cultures conidia are not very abundant.

*Classification:* The fungus belongs in the order Moniliales (Hyphomycetes) of the Fungi Imperfecti, and on account of the septate condition of the spores would have to be placed in the Moniliaceae-Hyalodidymae group. The fungus, however, seems to resemble more closely certain of the organisms with single-celled spores found in the group, Moniliaceae-Hyalosporae, such as *Physospora* and *Asterophora*.

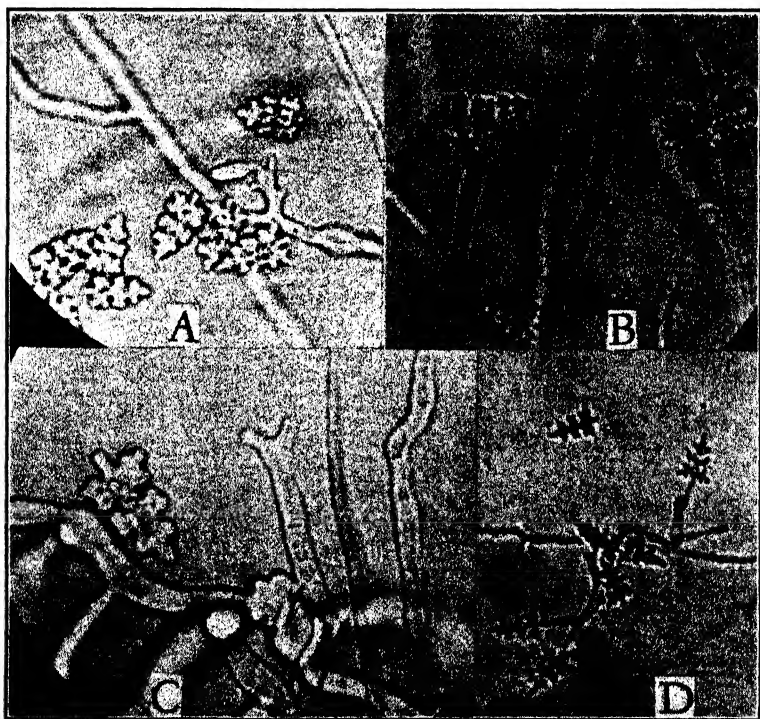


FIG. 1. Conidia and conidiophores of *Dendrosporium lobatum* from agar cultures. A and B,  $\times 750$ ; C,  $\times 1200$ ; D,  $\times 420$ .

**Dendrosporium** gen. nov.

Vegetative hyphae septate. Conidiophores similar to vegetative hyphae, variable in length, septate, often branched, with sterigmata near the apex. Conidia hyaline, flattened, deeply constricted, pedicellate, one-septate, one to several on each conidiophore.

**Dendrosporium lobatum** sp. nov.

Young colonies on beanpod agar closely appressed at the margins, white to creamy white, centers somewhat raised, aerial growth scanty. Older cultures grayish. Mycelium septate, hyaline when young, later becoming closely septate with brown, swollen cells, chlamydospore-like in appearance. Sporulation profuse in young cultures, very scanty in old cultures. Conidiophores approximately the same thickness and structure as the mycelium, developing as branches from the mycelial threads, septate, branched, very variable in length, hyaline. Conidia hyaline, deeply constricted so that there are usually three lobes on each side, the basal lobes being the largest, flattened to slightly concave or convex, pointed at the apex, pedicellate, uniseptate, the septum just above the basal lobes, the two cells being of unequal size, borne on slender sterigmata, one to several on each conidiophore,  $3.4\text{--}4.4 \times 6.8\text{--}10.2 \times 10.2\text{--}15.3 \mu$ , average about  $3.9 \times 7.8 \times 12.2 \mu$ .

Saprophytic, cultured from dead or dying bark of pear, *Pyrus serotina*. Type material in form of dried agar cultures, deposited in Mycological Collections, Bureau of Plant Industry, Washington, D. C.

DEPARTMENT OF BOTANY,

LOUISIANA AGRICULTURAL EXPERIMENT STATION,

BATON ROUGE, LOUISIANA

## NOTES AND BRIEF ARTICLES

### MYCOLOGIA

#### SPECIAL OFFER

During the Sixth International Botanical Congress in Amsterdam a special offer was made on back sets of *Mycologia* as follows: Volumes one to twenty-four were offered at fifty dollars (\$50.00), which is about half price. With every such order a copy of the recently published Twenty-Four Year Index, beautifully bound in red fabrikoid (value three dollars and fifty cents, \$3.50), will be given free. The response to this was so favorable that the Managing-Editor has decided to hold the offer open for a limited time, the time depending on the rate of sales. This is to enable members of the Mycological Society of America, who do not have specimens for exchange, to secure the early volumes at the lowest possible cost. If only a partial set is desired the rate per volume will be the same. Also a reasonable amount of time will be allowed for payment.—FRED J. SEAVER.

#### A CORRECTION

Since the publication of the name *Sphaerella* (*Mycosphaerella*) *dubia* L. E. Miles (Trans. Ill. Acad. Sci. 10: 250. 1917) antedates the publication of *Mycosphaerella dubia* Wolf (*Mycologia* 27: 347-356. 1935), it becomes necessary to assign another name to the perfect stage of *Cereospora Rubi*. The name ***Mycosphaerella confusa*** is proposed.—FREDERICK A. WOLF.

#### FUNGI OF SOUTH AUSTRALIA

Under the title "Toadstools and mushrooms and other larger fungi of South Australia" by J. B. Cleland, the South Australian branch of the British Science Guild has issued an attractive and useful work. Part I, issued in 1934, includes introductory material and the systematic treatment of the Agaricaceae. Part

II, issued in 1935, treats of the remaining Basidiomycetes, exclusive of the rusts and smuts, and, in addition, devotes a few pages to the Ascomycetes and Myxomycetes. The two parts include ten colored plates after paintings by Miss P. Clarke and seventy-seven excellent figures, mainly from photographs, although a number are reproductions in black and white of paintings by Miss Clarke. Complete descriptions are given of 581 species, of which all but seventeen are Basidiomycetes. The parts are sold for five shillings each, less than the cost of publication, and may be had from the Government Printer, Adelaide.—G. W. MARTIN.

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#### LEPIOTA MORGANI IN SOUTHERN CALIFORNIA

The species *Lepiota Morgani* (Peck) Sacc. (*Chlorophyllum molybdites* (Meyers); *Lepiota chlorospora*, Copeland) has been collected during the late summer and autumn for several years in the avocado orchard at the Citrus Experiment Station. This orchard is irrigated but receives no cultivation. In August, 1935, the fungus also developed on the campus of the Citrus Station, and on several of the lawns in Riverside, California. It also was collected several different times on the lawn of the State Hospital at Patton, California.

Lee Bonar, University of California, has recently stated in correspondence with the author, that he has received specimens of *Lepiota Morgani* collected in the vicinity of Los Angeles, Pasadena, and San Diego, but has no record of its occurrence in middle or northern California. The dimensions of the cap of the California fungus were 5–15 cm. The spores in mass were green and the pileus had the irregular scales.

*Lepiota Morgani* seems to thrive in the warmer climates and is considered by some to be of tropical origin. Under the name *Lepiota chlorospora* it has been listed from the Philippine Islands by Copeland (Ann. Myc. 3: 28, 1905) and was more recently found there by Graff (Mycologia 19: 322–326, 1927). It has been reported by Parks from Tahiti (Univ. of Calif. Publ. Bot. 12: 53, 1926). Murrill (N. Am. Flora 10: 64, 1914) gives its distribution as New Jersey to Iowa and southwest to Arizona, Texas, the West Indies, and Brazil.—CLAYTON O. SMITH.

## MORE PAVEMENT BREAKERS

F. J. Seaver recently (*Mycologia* **27**: 82-83, 1935) called attention to a report of *Coprinus comatus* ruining tennis courts in England and there have been similar records of fungi breaking up and demolishing pavements and other similar obstructions to their growth, over a period of more than 100 years. Where definitely named, the fungi involved in the several accounts examined have been members of the *Agaricaceae*, notably *Agaricus* and *Coprinus*. A case has recently occurred, however, involving members of the *Lycoperdales* rather than of the *Agaricales*. The condition in question was called to our attention by Mr. Ernest P. Walker, Assistant Director of the National Zoological Park of the Smithsonian Institution, at Washington, D. C. Fungi were found at two points breaking through bituminous macadam pavement which had been laid to a depth of approximately three inches. In the first instance three "eggs" of a phalloid later determined as *Ithyphallus Ravenelii* (Berk & Curt) Fischer were found. The volva of one was broken away to a limited extent, but the others showed no ill effects from their rough treatment of the pavement. Not over fifty feet away a similar break in the pavement revealed the top of a puff-ball, which on closer examination proved to be a moderately sized specimen of *Scleroderma Geaster* Fries. About a square foot of the pavement was disturbed in each case by cracking, and the broken edges forced upward and away from the developing fruiting bodies of the fungi. Due to cool, dry weather prevailing at the time, both fungi failed to complete their development after breaking through the macadam barriers.—JOHN A. STEVENSON.

## CHYTRIDIACEOUS FUNGI FROM TWO UNUSUAL SUBSTRATA

In my attempts to find in this country certain peculiar aquatic Phycomycetes described by earlier European investigators, I have been led to an examination of two rather unusual substrata, namely, marine algae and the cast-off larval integuments of certain fresh-water insects. These have been so productive of little-known types that it has seemed worth while to record the occurrence in our country of the fungi found on them. With the

exception of *Chytridium Polysiphoniae* Cohn, none of the species listed here has, to my knowledge, been heretofore recorded from the United States.

#### MARINE FUNGI

All of these were found in the vicinity of Woods Hole in the course of an investigation carried on at the Woods Hole Oceanographic Institution during the summer of 1934. A full account of this work will be shortly forthcoming.

The following species were found:

FUNGUS	SUBSTRATUM
1. ? ( <i>Pleotrachelus</i> ) <i>tumaeformis</i> (Magn.) Peter.....	<i>Ceramium diaphanum</i>
2. ? ( <i>Pleotrachelus</i> ) <i>sphacellarum</i> (Kny) Peter.....	<i>Sphacellaria radicans</i>
3. ? ( <i>Pleotrachelus</i> ) <i>Andréi</i> Lghm.....	<i>Ectocarpus siliculosus</i>
4. <i>Rhizopodium globosum</i> (Br.) Schroet.....	<i>Bryopsis plumosa</i>
5. <i>Rhizopodium discinctum</i> Peter.....	<i>Polysiphonia</i> sp.
6. <i>Chytridium Polysiphoniae</i> Cohn.....	<i>Polysiphonia</i> sp.
7. <i>Ectrogella perforans</i> Peter.....	<i>Striatella unipunctata</i> <i>Licmophora Lyngbii</i>
8. <i>Petersenia lobata</i> (Peter.) Sparr.....	<i>Callithamnion roseum</i>
9. <i>Sirolopidium Bryopsisidis</i> (de Bruyne) Peter.....	<i>Bryopsis plumosa</i>
10. <i>Pontisma lagenidioides</i> Peter.....	<i>Ceramium diaphanum</i>

#### FUNGI IN THE INTEGUMENTS OF INSECTS

This material was collected in New Hampshire and on Cape Cod, Mass.

1. *Asterophlyctis sarcophtoides* Peter. (N. H., Mass.).
2. *Rhizoclostridium globosum* Peter. (N. H., Mass.<sup>1</sup>).
3. *Siphonaria variabilis* Peter. (N. H.).
4. *Rhizidium mycophilum* Br. (N. H.<sup>1</sup>).
5. *Obelidium mucronatum* Nowak. (Mass.).

On both types of substrata certain forms were observed which have not hitherto been described and hence, will necessitate a full account of their morphology.—F. K. SPARROW, JR.

<sup>1</sup> These two species have been found by me on similar substrata in the vicinity of Cambridge, Eng. during the summer of 1935.

## HELVELLA PALUSTRIS IN VIRGINIA

This little known species was described by Peck<sup>1</sup> in 1880 from specimens found growing among mosses and liverworts at Manlius, N. Y., and has apparently been reported but once since, in 1931 by Anderson and Ickis<sup>2</sup> based upon a single specimen found at Pelham, Mass., which for reasons suggested below is but doubtfully referable to this species. Two specimens recently found by H. A. Allard, in Virginia, in the George Washington National Forest along Hone Quarry Creek (Rockingham Co., Sept. 8, 1935) resemble closely Peck's illustrations and are consistent with his description.

These two specimens are smaller than those described by Peck, but that is scarcely significant. The form of pileus and stipe and the peculiarly straight, sharp and uniform fluting of the stipes in the Virginia specimens agree perfectly with Peck's illustration of these features. The paraphyses and spores look like those in Peck's figure. The spores of the Virginia specimen measure  $15\text{--}18 \times 11\text{--}12 \mu$ , and compare favorably with Peck's description and illustrations in the ratio of the two axes although they are somewhat smaller. Peck's description notes ascospores  $.00065\text{--}.0008 \times .0005$  in. (*i.e.*  $18.5\text{--}20.3 \times 12.7 \mu$ ). Measurement of the spores in his illustration evaluated in terms of his magnification give  $17.5\text{--}20 \times 11.2\text{--}12.5 \mu$ . Through the courtesy of Dr. H. D. House it has been possible to examine ascospores from Peck's original specimens; these spores measured under the same conditions (*i.e.* in water)  $15\text{--}20 \times 11\text{--}12 \mu$ , chiefly,  $16\text{--}18 \times 11\text{--}12 \mu$ . All these measurements are quite different as regards the ratio of length to width from that noted by Seaver<sup>3</sup> of spores as  $9 \times 18 \mu$  and by Anderson and Ickis (*l.c.*) of  $14\text{--}18 \times 7\text{--}10 \mu$ . Seaver (*l.c.*) has suggested the possibility that Peck's species may be referred to Schaeffer's<sup>4</sup> *H. pallescens*, a European fungus which is not particularly like *H. palustris* except for flutings of the stipe, which are rounded and not sharp angled, if the evidence afforded by

<sup>1</sup> Peck, C. H. Ann. Rep. N. Y. State Mus. 33: 31, *pl.* 2, *f.* 16-18. 1880.

<sup>2</sup> Anderson, P. J. & Ickis, M. G. Mycologia 13: 201-239. 1921 (pp. 214-215).

<sup>3</sup> Seaver, F. J. North American Cup-fungi 247-248. 1928.

<sup>4</sup> Schaeffer, J. Fung. Bav. et Palat. Icon 4: T. 322. Index, p. 114 (ed. nov. C. H. Persoon), 1780. (Apparently identical with Ed. 1, 1774.)



Schaeffer's original illustration and by several others of more recent date is considered. Rehm,<sup>5</sup> however, notes spores of  $14-16 \times 10-12\mu$  for *H. pallescens* which would be close to those of *H. palustris*. The possibility of referring the New York and Virginia fungus to *H. Queletii* Bres.<sup>6</sup> as is suggested by Anderson and Ickis for the Massachusetts specimen would appear more pertinent except that this European species possesses filiform paraphyses while those of *H. palustris* are clavate, and the flutings of the stipe as illustrated are less numerous and more rounded rather than sharp edged as in *H. palustris*.

Everything considered it would seem that *H. palustris* Peck, as represented by the original specimens from New York and by Allard's from Virginia is a distinct species and not referable to any known from Europe, justifying Peck's recognition of it as new. Hitherto found only in moist places, it may well be restricted to a particular habitat, but additional gatherings at the correct season should extend its range considerably further.—W. W. DIEHL.

#### THE GENERA PHILLIPSIA AND COOKEINA

Under the title "The genera *Phillipsia* and *Cookeina* in Netherlands India" K. B. Boedijn (Bull. Jardin Bot. Buitenzorg III. 13: 57-76. 1933) gives an account of his studies on the above genera in the East Indies. It is interesting to note that practically all of the species reported by the writer in North American Cup-fungi are known to occur also in the East Indies. In fact, it is likely that the species of these genera occur in the tropics throughout the world.

Boedijn agrees with the writer in placing these genera in the operculate Pezizaceae instead of with the inoperculate Helotiaceae, as was done by Lindau in Engler and Prantl's *Natürlichen Pflanzenfamilien*. He disagrees with Clements and Shear in uniting the genera *Sarcoscypha* (*Plectania*) and *Cookeina* merely because of a superficial resemblance, since there are marked differences which warrant a separation of the two.

<sup>5</sup> Rehm, H. *Ascomyceten* in Rabenh. Krypt.-Fl. 2<sup>te</sup> Aufl. 1: Abt. 3, 1188-1189. 1896.

<sup>6</sup> Bresadola, J. *Rev. Myc.* 4: 211, 1882; and *Fung. Trident.* 2: 19, T. 92, 1883.

There are certain morphological characters definitely associated with the species of these genera. The first of these is the peculiar striate markings of the spores. Boedijn states "Seaver seems to be the first to have proven its constancy for the above mentioned species." Perhaps it would be better to say that the writer was the first to have called attention to this character. Boedijn claims, however, that the striations are made up of shallow grooves and delicate ridges, which the writer had not been able to observe.

Another character of importance is the eccentrically placed ascostome, which in North American Cup-fungi the writer has referred to as a definite morphological character associated with the species of these genera. Buller in his *Researches on Fungi* (Volume 6: 255) questions this statement, claiming that the eccentricity of the ascostome depends upon the direction of light. Boedijn states "In this connection it may be noted, that on a radial section of a fruitbody all opercula are pointed to the border of the apothecium." Apparently its position neither depends upon the direction of light or on the form of the cup in the plants of these particular genera. In facing the outside of the cup they would have a tendency to scatter the spores rather than to throw them straight up from the surface of the apothecium.

The writer (l.c.) has also noted a great discrepancy between the size of the ascostome and the spore, which has passed through it. Boedijn claims that this apparent discrepancy in size is due to the fact that the writer made post-mortem examinations. He states "The ascusporus, which in living asci is just wide enough for the passing of the spores, shrinks considerably after ejaculation." In another place he states "In two instances only 7 of the spores were ejaculated at once, whereas the remaining spore first stuck in the poremouth and was shot away a short time afterwards. This observation too shows that the ascostome shrinks after spore ejection."

If the ascostome contracts after seven spores have been ejaculated, and is compelled to stretch to allow the remaining spore to pass through, as is indicated by Boedijn (FIG. 5g), how does he know that the ascostome does not contract after each spore ejection, even though the spores appear to pass through in

one series? In fact, Boedijn's own drawings (FIG. 5) indicate the same discrepancy in size between the ascostome, or operculum, and the spore, as was indicated by the writer in North American Cup-fungi.

The statement made by Boedijn that the ascusporus, or ascostome, in living asci is just wide enough for the passing of the spores, but shrinks considerably after ejaculation, is misleading since before the ejaculation of the spores there is no ascostome. Furthermore, the size of the operculum, which usually adheres is an approximate index to the original size of the ascostome, and this is usually not more than half the diameter of the spore. The writer still maintains that this discrepancy in size does exist, and that the expansion and contraction of the ascostome is one of the factors which contributes to the forcible ejaculation of the spores.

Boedijn claims that *Phillipsia gigantea* Seaver is a synonym of *Phillipsia domingensis*, since it differs only in size and intermediate forms have been found. He also claims that *Cookeina tetraspora* does not belong to the genus *Cookeina*, although he does not state to what genus it does belong. The writer noted when this species was described that it did not fit well in the genus *Cookeina*, but it seemed to be the only genus to which it could be referred. It has much in common with other species of *Cookeina*.

The paper is a decided contribution to our knowledge of the species of these two tropical genera, and it is hoped that some student in our own West Indies will continue these studies from fresh material, as has been done by Boedijn in the East Indies.—  
FRED J. SEAYER.

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#### REPORT ON THE TAXONOMIC SESSIONS OF THE INTERNATIONAL BOTANICAL CONGRESS

The International Botanical Congress at Amsterdam, as one looks back on it, was marked by a wonderful spirit of coöperation and a desire to stabilize nomenclature. This fact was pointed out by the large number of proposals which amounted mostly to the change of wording that would make clear and more precise the meaning and intent of the existing rules. Therefore, with but few exceptions the points raised were of minor importance and for the most part these were practically decided by the

Executive Committee of the Congress and the Executive Committee of Nomenclature before the meetings, and readily accepted during the meetings.

The matter of *nomena specifica conservanda* seems to have been fairly definitely settled by the rejection of proposals that were brought forward to validate this procedure. On the other hand, the list of *nomena genera conservanda* remains to be settled and to this aim it was proposed and carried that names to be conserved before final acceptance by the congress should be submitted to the careful scrutiny of each group of botanists, *i.e.* phanerogamic, cryptogamic which was divided into three sub-groups, fungi, algae, and bryophytes, paleobotanic and the like. In this manner the hasty acceptance of genera to be conserved was avoided and violence was not done to the nomenclature of the specialized groups.

The dates of departure of the various groups of plants were left for the consideration of special committees for each of the special groups. At the mycological section on nomenclature it was voted that the whole matter be thoroughly studied in order to obtain more satisfactory dates of departure since there was considerable dissatisfaction with the present dates. It is hoped that this committee<sup>1</sup> will act with promptness but not undue haste in determining the date of departure whether for each major group of fungi or for the fungi as a whole.

The proposal that Friesian subgenera of *Agaricus* be recognized as genera, with Fries as the authority, although receiving some support because of the ease and simplicity of settling the question in this way, nevertheless was rejected on the ground that it was unscientific, inaccurate, and led to carelessness in citation. This question was therefore turned over for consideration to the same committee that is to handle the problem of the dates of departure.

The principle of usage in the choice of type species to represent genera was strongly opposed since it was felt that usage in different countries varied greatly and hence that method

<sup>1</sup> Ramsbottom, J., England; Maire, R., France; Shear, C. L., United States (Chairman); Wakefield, E. M., England; Pilat, A., Czechoslovakia; Seaver, F. J., United States; Boedijn, K. B., Holland and Java; Nannfeldt, J. A., Sweden; Ciferri, R., Italy; Trotter, A., Italy; Weston, W. H. Jr., United States; Lutjeharms, W. J., Holland.

could not help in stabilizing nomenclature. Therefore this subject was also referred to the committee on mycological nomenclature.

The conditions for the effective publication of names has been somewhat amplified by the statement to the effect that when separates appear in advance of books or publications, the date of the name starts from the date of publication of the separate. It was made clear that the date must be definitely indicated in print on the reprint. At the same time the separates should be sent to each of the selected institutions which have been provisionally listed. The list of institutions however, was found to be far too poorly representative of the various countries and the opinion was that the number of institutions be increased and that botanical societies and institutions be invited to coöperate in naming the additional herbaria and libraries.

Citation of misdeterminations in literature came up for considerable discussion which ended in a recommendation to the effect that the manner of citing such misdeterminations be left to the discretion or preference of the individual, but however cited, the misdeterminations must be kept separate and distinct from the actual synonymy of the species.

One of the most important discussions centered around article 54. The proposal B54 reads as follows: "When on transference to another genus the specific epithet has been applied erroneously in its new position to a different species, the new combination must be retained for the plant on which the epithet was originally based and must be attributed to the author who first published it." This article unfortunately was passed in spite of the fact that it does violence to the type concept and is more than likely to increase confusion and perpetuate errors unless *the original type specimen or description is consulted and not that upon which the new combination was made*. The one advantage, hardly scientific in point of view is that it simplifies the task of keeping indices. The alternative proposal A54 reads as follows: "When on transference to another genus, the specific epithet has been applied erroneously in its new position to a different plant, the combination must be retained for the plant on which the epithet was originally based and must be attributed to the author who

first correctly used the combination for the right plant. The incorrect use must not be treated as an earlier homonym." In view of the fact that the type method has been accepted by all but a few die-hards and since article A54 is the only logical outcome of the method, it is greatly to be hoped that article 54 as at present accepted be reconsidered before too great harm results.

As a check on careless work and premature publication, it was the definite opinion of the majority of delegates that the publication of eventual names be suppressed, and to this end it was ruled that only the first of two or more names for a single species when published at the same time, be taken into consideration. For example, as the writers understand the ruling, if an author publishes a new name and is not sure as to the generic position of the species and he simultaneously publishes the species under two generic names, then only the first name need be considered and subsequent investigators may or may not accept the other name should it later be shown that it is more appropriate. In other words, it is felt that a species cannot be in two genera at the same time.—D. H. LINDER, F. J. SEAVER.

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#### SCIIZOPARME STRAMINEA AND NECTRIELLA Versoniana IDENTICAL

A reprint of a paper "A dry rot of pomegranate fruit caused by *Zythia Versoniana* Sacc.," by F. L. Tai and C. C. Cheo, has been received recently from Prof. Tai, now of the Institute of Agricultural Research, Tsing Hua University, Peiping, China. The authors state that the losses due to this fungus may be from thirty to forty-nine per cent for some varieties. They also note that T. F. Yu, under the title "Notes on the storage and market diseases of fruits," Jour. Agr. Assoc. of China **123**: 16-27, 1934, reports having observed a serious storage disease caused by this same fungus.

Some years ago, the writer, in coöperation with the Office of Fruit Diseases Investigations, U. S. Department of Agriculture, began working at odd times on rots of strawberries found in the markets of New York City. A fruit rot first picked up in 1918 was not found especially destructive, but the fungus causing it

was very interesting. Pure cultures were obtained and sound strawberries were inoculated to prove that the characteristic rot was caused by this particular fungus.

The rather dark greenish or olivaceous pycnidia that developed on the fruit were densely crowded together. They could be readily distinguished from fruit bodies of other fungi common on strawberries by the mass of light-colored tissue which surmounted the pycnidium in each case. This overgrowth resembled a little crown surrounding the ostiole. Although the wall of the mature pycnidium was somewhat carbonaceous, suggesting a *Phoma* type, the fleshy appearance, due to the crown of sterile tissue, would lead one to place the fungus in *Zythia*. In July 1920, some perithecia associated with the same kind of pycnidia originally found on rotting strawberries were found on strawberry leaves. The connection between the pycnidial and perithecial forms was established culturally. The ascospores germinated readily even before they were discharged from the ascus. Asci still containing spores were floated out from crushed perithecia so that they could be isolated. The eight spores included in an ascus were transferred together with the hope that if the species were heterothallic one might obtain perithecia with greater certainty. About 100 "single ascus" cultures were obtained, but in no case were perithecia developed. On the other hand large numbers of pycnidia matured, and spores from these were used to inoculate strawberry fruits. There was no question that the two fruiting stages belonged to the same fungus.

The formation of the central cavity in the pycnidium, the growth of the buffer tissue, the formation of the ostiole and other features were studied. Parallel studies were also made of the perithecial fruit bodies found on leaves of strawberries, roses and various other plants. A most interesting series of parallelisms could be followed. These features were described and illustrated by the writer under the title—"Origin of the central and ostiolar cavities in pycnidia of certain fungous parasites of fruits" (Jour. Agr. Res. 23: 743-760, fig. 1, pls. 1-6. 1923). As the writer was anxious for a specific name to which the fungus could be referred in this paper, it had been submitted to Dr. C. L. Shear

for identification. As he was unable to determine the species from any description which we could find in the literature, he described it as new and made a new genus *Schizoparme* based on this species, and called it *Schizoparme straminea* (Shear, C. L. Life histories and undescribed genera and species of fungi. *Mycologia* 15: 120-131. 1923).

Reading the description of the fungus causing the dry rot of pomegranate as given by Tai and Cheo, and comparing their description and figures in their plates 2 and 3 with those given by Shear, and with those accompanying the article by the writer, and referred to above, one must be fully convinced that *Nectriella Versoniana* Sacc. & Penz. (*Michelia* 2: 256. 1881) and *Schizoparme straminea* Shear are one and the same fungus. As further evidence on the question one need only to compare the specimen in Saccardo's *Myc. Ven.*, 1484, *Nectriella Versoniana* Sacc. & Penz., with specimens of *Schizoparme straminea* Shear in the Mycological Herbarium in Washington. Or one can readily obtain the fungus from strawberries in the markets of New York City, if he examines shipments arriving from Florida in late winter. The pycnidial stage *Phoma (Phomopsis) Versoniana* Sacc. (*Michelia* 2: 272. 1881), was later transferred to *Zythia* (Sacc. *Syll.* 3: 614. 1884).

Tai and Cheo state that the fungus tends to become zonate in culture and that the pycnidia are often crowded together. These features were also brought out in our own illustrations. Tai and Cheo figure several asci showing the two small very characteristic bodies, "favolae," at the upper end of the ascus. In the original description by Saccardo and Penzig (*Michelia* 2: 256) this feature is also mentioned. My own cytological preparations show these bodies (ascostome collars?) very distinctly.

When the pycnidium develops on strawberry fruits or on leaves, the stromatic tissue is not very evident and the pycnidial cavity is largely schizogenetic. The buffer tissue develops as a "circumostioilar epistroma," as Shear calls it, a very interesting and characteristic feature.

*Macrophoma Granati* (Sacc.) Berl. & Vogl. as described and illustrated by Bubak (*Bull. Herb. Bois.* II. 6: 475, pl. 15, figs. 5-8) is clearly the same thing. His figure 5 shows exactly what we



find in sections of the pycnidia on strawberry or on leaves of *Rhus*. Bubak's plates 14 and 15 are transposed as can be seen from the legends. In view of the world wide distribution of the fungus and the fact that we have found it on species of such distantly related genera as *Eucalyptus*, *Vitis*, *Rhus*, *Fragaria* and *Salix*, it is very probable that the fungus has been described under several other names. Examination of Saccardo's M. V. 514 would no doubt prove that *Phoma Granati* Sacc. (N. Gior. Bot. Ital. 8: 200. 1876) and *Phoma Versoniana* are synonymous; if so the specific name *Granati* logically should take precedence over *Versoniana*. I am informed that the present International Botanical Rules require that the first specific name applied to the perfect or ascocarpic stage must be used. By what sort of reasoning such a rule can be defended is beyond our comprehension.

After the above note was in type Dr. D. H. Linder kindly compared specimens of *Phoma Granati*, M. V. 514, and *P. Versoniana*, M. V. 1484, in the Herbarium of Cryptogamic Botany, Harvard University. It is his opinion that they are identical. He expresses some doubt, however, that *Phoma Granati* is connected with the *Nectriella*. He was unable to find ascospores of the *Nectriella* in either specimen. The specimen of No. 1484 in our collection at The New York Botanical Garden does show characteristic asci of the *Nectriella*.—B. O. DODGE.

## THE MYCOLOGICAL SOCIETY OF AMERICA

(WITH 2 FIGURES)

### SUMMER FORAY

Pursuant to notices of time and place in Mycologia and Science the Mycological Society of America held a four-day summer meeting at Ithaca, N. Y., beginning on Tuesday morning the 20th of August, 1935. It was the third of such summer meetings or forays held since the organization of the Society in 1931. The first took place in North Carolina with headquarters at the Highlands Biological Laboratories and Museum, the next at the summer camp of Professor F. C. Stewart on Seventh Lake in the

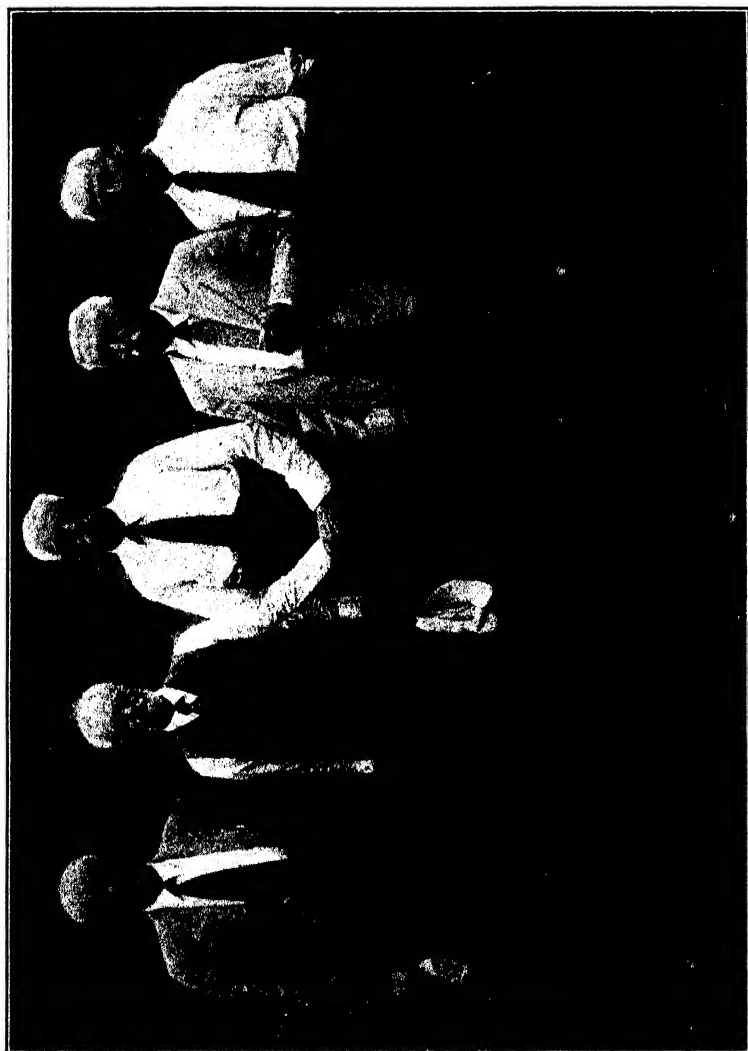


FIG. 1. SUMMER FORAY—1935. *H. C. Beardslee, John Dearness, F. C. Stewart, J. C. Arthur, E. A. Bessey.*

Adirondack Mountains in northern New York. This year headquarters were established in the convenient and well equipped laboratories of the Plant Science Building of Cornell University. Thus far these Forays have combined the pleasure of a summer holiday and the benefits of social intercourse among people of similar interests, with the advancement of knowledge of their favorite science.

Perfect weather during the whole week of this meeting favored traveling to and from the meeting place as well as the carrying out of the definite day-by-day program. Cars started every morning at eight or nine o'clock to convey members to designated collecting fields, returning at noon. The afternoons were devoted to investigating at the laboratories with microscopes, library facilities, and other necessary equipment, the amply sufficient quantity of material collected. Electrically operated driers for the studied and identified "fleshies" were kept running day and night.

Tuesday evening an informal reception for the visiting mycologists and their families was given by the staff members, graduate students, and wives of the Department of Plant Pathology. Additional guests included the members of other departments of the large biological group at Cornell. Wednesday evening was set aside for the making of mycological demonstrations of general interest. President B. O. Dodge discussed certain aspects of his research on *Neurospora*, and illustrated with photographs, cultures, and slides the points emphasized. Mr. Robert Hagelstein displayed an attractively mounted collection of the Myxomycetes of New York State, which included specimens of practically all North American genera and species.

If there are any better collecting fields than in the district around Ithaca they must be very rare; nothing is lacking in the completeness and convenience of the laboratory equipment for botanical work in the Plant Science Building of Cornell University; there was no lack of sympathy, even of generosity, on the part of the University authorities, and yet with all these favorable factors the Foray could not have been such a success without the preparatory and continued efforts of Professors Whetzel and Fitzpatrick who composed the local committee on arrangements.

They knew the resources well and possessed the knowledge, will, and skill to make success complete.

Contributing to the pleasure of visiting members' wives who were not especially interested in fungi was a social program in which the homes of the local professors were opened for entertainment. On Thursday evening all members of the Foray went to Taughannock Falls State Park, a beautiful reservation on Cayuga Lake, for a picnic supper. Brief addresses were given by President Dodge, Doctor Arthur, and others. At the Friday afternoon recess for "a cup of tea" the Secretary was instructed to convey to the Head of the Department of Plant Pathology, the Dean of the College of Agriculture and the President of Cornell University the cordial thanks of the members of the Foray for the hospitality of the University.

During the month preceding the meeting, rainfall in the vicinity of Ithaca had been below normal. Still the collecting in most groups was satisfactory and in some was excellent. Though the mycological interests of members of the Foray were various, perhaps the greatest number gave attention to the fleshy fungi. The following list has been compiled by Professor Fitzpatrick from data provided by various individuals and received in time for this report. It contains the names of those species which for one reason or another attracted attention.

#### NOTEWORTHY COLLECTIONS

MYXOMYCETES: *Lamproderma muscorum* (Lév.) Hagelstein, *Comatricha Rispaudii* Hagelstein, *Clastoderma Debaryanum* Blytt, *Kleistobolus pusillus* Lipp., *Licea biforis* Morg., *Physarum leucopus* Link, and *P. penetrale* Rex.

About 600 distinct fruitings were collected by Robert Hagelstein and Joseph H. Rispaud. These represented 32 genera, 119 species, and 7 varieties.

ASCOMYCETES: *Endogone macrocarpa* Tul., coll. Whetzel; *Sphaerospora brunnea* (Alb. & Schw.) Masee, coll. Connors; *Gorgoniceps* n. sp., coll. Dearness; *Texiffigia Corni* (Auersw.) Toro, coll. Dearness; *Baeomyces roseus* Pers., coll. Dearness; *Spathularia velutipes* Cooke & Farl., coll. Viégas; *Gloeoglossum*

*affine* Durand, coll. Conners; *Cordyceps ophioglossoides* (Ehrh.) Link, on *Elaphomyces granulatus* Fr., coll. Welch; *Hypomyces hyalinus* (Schw.) E. & E., coll. Dearness.

FUNGI IMPERFECTI: *Hainesia Lythri* (Desm.) v. Höhn. on *Steironema ciliatum* (L.) Raf., coll. Conners; *Stephanoma strigosum* Wallr. on *Lachnea hemisphaerica* (Wigg.) Gill., coll. Conners; *Cylindrosporium acerinum* Peck on *Acer spicatum* Lam., coll. Dearness.

UREDINALES: *Puccinia tenuis* (Schw.) Burr. on *Eupatorium urticaefolium* Reich., coll. Conners; *P. recedens* Syd. on *Senecio aureus* L., coll. Arthur and Kern; *Pucciniastrum Myrtilli* (Schum.) Arth. on *Vaccinium pennsylvanicum* Lam., coll. Dearness.

AGARICACEAE: *Collybia dryophila* Fr. with convoluted excrescences (*Tremella mycetophila* Peck) on pileus and stem; *Lactarius vellereus* Fr., bearing similar excrescences on the pileus, coll. Stewart; *Cantharellus floccosus* Schw., coll. Dearness; *Lactaria Indigo* Schw., *L. chrysorhea* Fr., *L. atroviridis* Peck (These three species regarded by Miss Burlingham as outstanding among the 35 species of *Lactaria* and *Russula* collected by her.); *Entoloma cuspidatum* Peck, *E. luteum* Peck, *E. salmoneum* Peck, *Cortinarius bolaris* Fr., *C. lilacinus* Peck, coll. Beardslee.

POLYPORACEAE: *Polyporus Berkeleyi* Fr. coll. Burnham; *Polyporus Montagnei* Fr., coll. Viégas; *P. flavovirens* Berk. & Rav., coll. H. A. C. Jackson; *Boletus* n. sp.? (This species lying near *B. chrysenteron* and *B. fumosipes*, regarded as the most interesting of 24 species of this genus collected by Snell); *Boletinus pictus* Peck, coll. Stewart; *Poria eupora* Karst., coll. Lisi.

HYDNACEAE: *Hydnum fennicum* Karst., *Hydnellum velutinum* Fr. *H. humidum* Banker, *H. scrobiculatum* Fr., *H. zonatum* (Batsch) Karst., *Phellodon albo-niger* (Peck) Banker, *P. velereus* (Peck) Banker (all collected by Beardslee); *Hydnum imbricatum* L. coll. Dearness.

BASIDIOMYCETES (Miscellaneous): *Eocronartium muscicola* (Pers.) Fitzp., coll. Dearness; *Sebacina incrustans* (Pers.) Tul., coll. Lisi; *Tremellodendron pallidum* (Schw.) Burt, coll. H. A. C. Jackson; *Hypochnus botryoides* (Schw.) Burt, *H. fumosus* Fr., coll. Lisi; *Clavaria amethystina* (Batt.) Bull.—JOHN DEARNESS.

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVIII MARCH-APRIL, 1936

NO. 2

## PHYLOGENETIC SIGNIFICANCE OF THE PORES IN UREDIOSPORES<sup>1</sup>

GEORGE BAKER CUMMINS<sup>2</sup>

A prominent feature of the urediospores of most species of the Uredinales is the presence of visibly differentiated areas in the walls of the spores through which germination takes place. The Tulasnes (35) first observed and illustrated these morphologic features in 1847 and applied the name of pores or oscules to them. Their taxonomic value in the rusts of grasses and sedges was pointed out by Arthur and Fromme (5) in 1915, and the possible importance of their arrangement was suggested by Fromme (19) in 1915 and again by Buller (10) in 1924. A comparative study of the pores of any number of genera or of a large number of species within a single genus has not previously been made.

While such a detailed study has not been made, the systematic value of the number and arrangement of the pores in urediospores

<sup>1</sup>Contribution from the Botany Department, Purdue University Agricultural Experiment Station, Lafayette, Indiana. Based upon a thesis submitted by George Baker Cummins to the Faculty of Purdue University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy, June, 1935.

<sup>2</sup>The writer is especially grateful to Dr. J. C. Arthur for his interest in this work and for his stimulating and constructive criticism. Without the privilege of such an association and without access to such an extensive collection as the Arthur Herbarium, the formulation of the relationships presented herein would not have been possible. It is also a pleasure to acknowledge the assistance given by Dr. R. M. Caldwell during the preparation of the manuscript.

[MYCOLOGIA for January-February (28: 1-102) was issued February 1, 1936]

has been attested by their almost universal inclusion in specific descriptions. The present clarity of specific limits in the rusts of grasses and sedges is, in large measure, the result of careful study of the pores in the urediospores. Aside from experiments establishing the alternate hosts no single feature has proved as helpful. Although granting the advance facilitated by the use of this character no data have been presented to validate such usage from other than a purely descriptive basis. The pores in the teliospores have often been employed in the interrelation of genera; those in the urediospores only rarely. It is possible, however, to accord phylogenetic importance to the number and arrangement of the pores in urediospores, as will be shown.

Both the number and the arrangement of the pores in the urediospores vary according to the species studied. The pores may be scattered, bizonate, equatorial, superequatorial, sub-equatorial or limited to a ring about the hilum. The number is also variable, ranging from a single pore to as many as twenty. The pores may be large and evident or small and obscure. A small, hyaline, cuticular cap is often present over the pore but may be wanting. Sculpturing on the wall of the spore may cover the area above the pore or an otherwise sculptured wall may be smooth around the pore. In the midst of this variability it is striking that this morphologic feature remains constant, with rare exceptions, for any given species. Such constancy, aside from being convenient for the systematist, may be indicative of phylogenetic value and if so should offer a means of reaching a better understanding of the interrelationships of the genera and species.

An attempt is made in the following pages to evaluate this morphologic feature and to explain the phylogenetic significance of the different numbers and arrangements of pores.

In order to reach the conclusions presented, it has been necessary to start from some basic assumption regarding the phylogeny of the rusts. The view that the rusts of the family Melampsoraceae are more primitive than those of the family Pucciniaceae has been accepted and the conclusions reached will be seen to require the acceptance of such a view as essentially valid.

The data presented in this paper were obtained chiefly from a

study of the rust flora of North America as presented by Arthur (2) in the North American Flora.

#### THE UREDIOSPORE-PORES OF THE MELAMPSORACEAE

The urediospores of 84 species in 14 genera of the Melampsoraceae of North America were examined. Visible pores were found to be characteristic of the spores of all of the genera, although they could not be definitely demonstrated in some species.

In preparing the urediospores for study they were mounted in a saturated solution of chloral hydrate and heated to the boiling point. At times it was necessary to repeat the heating. By boiling in this manner the outer, sculptured, cuticular layer can often be dissolved, as in *Chrysomyxa*. The pores are then visible in the inner wall of the urediospore. Spores devoid of their protoplasm offer the most favorable material for examination. Gentle pressure upon the cover slip will usually crack the wall of the spores sufficiently to liberate the contents. The above methods of treatment are helpful but main reliance must be placed upon a careful manipulation of the microscope, and the eye must be trained to see indistinct differences in the structure of the walls.

With the exception of verrucose urediospores, such as characterize *Coleosporium* and *Chrysomyxa*, the pore is usually covered by a small, hyaline, cuticular cap which protrudes beyond the uniform curvature of the wall and into which the pore does not extend. This cap or umbo may be similarly sculptured as the rest of the cuticular layer or it may be smooth. The cuticular caps expand in water and a careful search for them often gives an accurate impression of the position of the pores, even though the pores cannot be seen in the wall below.

Species with verrucose urediospores present the greatest difficulty. Neither the location nor the number of pores could be ascertained in most species of *Coleosporium*, but it is probable that all of them have several scattered pores. The spores of *Chrysomyxa* also are verrucose and have scattered pores. *C. Piperiana* has the largest number of pores of any rust studied and, while accurate counts are difficult, it is certain that there are often as many as 20.



There are three more or less distinct kinds of arrangement for the pores in the urediospores of the Melampsoraceae. All of the species in some genera have a like arrangement but in others the species may be divided into two groups (see table 1). The three arrangements may be designated as follows: (1) scattered, (2) in two fairly regular zones near the opposite ends of the spore and (3) equatorial. The arrangement may change from bizonate to scattered in spores which are nearly globoid, as previously pointed out by Moss (31) for *Milesia*. Most of the species of the Melampsoraceae have scattered or bizonate pores, while *Bubakia* is the only genus in which the pores are equatorial in all species.

The pores vary in number from four to twenty, with four being the characteristic number in species with equatorial pores, while five to eight is the commoner number in species with scattered pores and eight in species with two zones of pores.

Until recently the pores of the urediospores of the Melampsoraceae usually have been considered to be absent or invisible. However, Moss (31) studied the urediospores of *Hyalopsora*, *Milesia*, *Pucciniastrum* and *Melampsorella*, and found that pores were present and could be seen with considerable accuracy in the species studied. His observations agree in general with those of the writer. Cunningham (13) includes the number and position of the pores in his descriptions of the melampsoraceous species. *Chrysomyxa* is the only genus in which he found the pores to be too obscure to warrant a definite statement.

Illustrations also have given indications of the location of the pores in certain genera. For example, the figures published by Tulasne (34), Colley (12) and Bagchee (6) show the location of the pores for three species of *Cronartium*, and Bell's (8) illustrations are accurate for *Uredinopsis*. Hart (22) states that the pores are equatorial in *Melampsora Lini* but her illustrations do not entirely substantiate her written statement. Cunningham (13) also states that the pores are equatorial in *M. Lini* but during the present study they were found to be scattered, which is in agreement with other North American species of *Melampsora* and with Tulasne's (34) illustrations of two European species.

As a family the Melampsoraceae are characterized by urediospores with several, usually five to eight, scattered pores and by

a decided scarcity of species with equatorial pores. The arrangements of the pores are given in table 1 for the major general.

TABLE 1

THE RELATION BETWEEN THE LOCATION OF THE PORES AND THE SHAPE OF THE UREDIOSPORES IN 19 GENERA OF THE MELAMPSORACEAE AND PUCCINIACEAE

Genus	No. spp.	Average urediospore	Mean ratio of breadth to length	Arrangement of pores
<i>Hyalopora</i> .....	{ 2 1	$19 \times 28 \mu$ $18 \times 25$	1 : 1.47 1 : 1.39	equatorial scattered
<i>Uredinopsis</i> .....	5	$14 \times 42$	1 : 3.00	bizonate
<i>Milesia</i> .....	10	$18 \times 36$	1 : 2.00	bizonate
<i>Melampsoridium</i> .....	3	$11 \times 30$	1 : 2.73	bizonate
<i>Pucciniastrum</i> .....	{ 6 5	$14 \times 19$ $15 \times 27$	1 : 1.36 1 : 1.80	scattered bizonate
<i>Cronartium</i> .....	6	$18 \times 25$	1 : 1.38	bizonate
<i>Chrysomyxa</i> .....	9	$20 \times 32$	1 : 1.60	scattered
<i>Coleosporium</i> .....	27	$19 \times 25$	1 : 1.31	scattered
<i>Melampora</i> .....	{ 4 9	$16 \times 19$ $19 \times 30$	1 : 1.19 1 : 1.58	scattered bizonate
<i>Phakopora</i> .....	5	$17 \times 23$	1 : 1.35	scattered
<i>Bubakia</i> .....	2	$20 \times 29$	1 : 1.45	equatorial
<i>Pileolaria</i> .....	4	$24 \times 38$	1 : 1.58	equatorial
<i>Tranzschelia</i> .....	2	$19 \times 34$	1 : 1.79	equatorial
<i>Cumminsiella</i> .....	3	$19 \times 31$	1 : 1.63	equatorial
<i>Uropyxis</i> .....	6	$18 \times 25$	1 : 1.38	scattered
<i>Prospodium</i> .....	6	$23 \times 25$	1 : 1.09	equatorial
<i>Phragmidium</i> .....	15	$19 \times 22$	1 : 1.16	scattered
<i>Ravenelia</i> .....	{ 28 26 8	$17 \times 21$ $17 \times 28$ $16 \times 26$	1 : 1.24 1 : 1.65 1 : 1.63	scattered equatorial bizonate
<i>Puccinia</i> .....	{ 87 270 3	$22 \times 27$ $22 \times 28$ $23 \times 37$	1 : 1.23 1 : 1.27 1 : 1.61	scattered equatorial bizonate

#### THE UREDIOSPORE-PORES OF THE PUCCINIACEAE

The arrangement and number of pores in the urediospores of the Pucciniaceae have been given so commonly that an original study was necessary for only a minority of the species. While the outer cuticular layer is hyaline the remainder of the wall is usually pigmented. Since the pigment is not deposited in the pores they are more distinct than those of the colorless urediospores of the Melampsoraceae and special treatment is usually unnecessary.

Some genera have urediospores with scattered pores only, as *Uropyxis*, *Phragmopyxis* and *Phragmidium*. *Dicheirinia*, *Tranz-*

*schelia* and *Prospodium* have equatorial pores. The pores are equatorial or subequatorial in *Pileolaria*, either equatorial or bizonate in *Cumminsella*, and while difficult to observe in *Mainsia* and *Kuehneola* are probably equatorial, certainly so in some species. *Ravenelia*, *Puccinia* and *Uromyces*, all large genera, show many variations in the number and the arrangement of the pores in their urediospores, as well as diversity in other features.

As a family the Pucciniaceae are characterized by a decreasing proportion of species with scattered pores and by an increasing proportion of species with equatorial pores. When the pores are scattered the number is usually five to ten, when bizonate usually eight and when equatorial commonly two, three or four. The arrangement of the pores is given in table 1 for the major North American genera.

#### UREDIOspore-Pores AND THE SHAPE OF SPORES

There appears to be some correlation between the arrangement of pores and the shape of urediospores, in that globoid spores usually have scattered pores while ellipsoid, oblong or radially asymmetrical spores usually have zonate pores. In order to demonstrate this relationship, published measurements were assembled for 552 North American species. The species in each genus were divided into groups as follows: pores scattered, pores bizonate and pores equatorial. The average spore for each species was calculated, and from the total of these averages the dimensions of the average spore for each group were obtained. To facilitate comparison between genera, or groups within genera, the mean ratios of breadth to length were calculated from the average spore of each group. The data are given in table 1.

Summarization of the table accordingly as the urediospores have scattered, equatorial or bizonate pores gives the following figures. The dimensions (to the nearest whole number) of the average urediospores are  $18 \times 24 \mu$ ,  $20 \times 30 \mu$  and  $17 \times 34 \mu$ , and the mean ratios of breadth to length are 1 : 1.33, 1 : 1.5 and 1 : 2.0, respectively for the three groups. These data, based upon many species, indicate that the arrangement of the pores is related to the shapes of the spores, but a comparison of the above

average ratios with the ratios for individual genera shows that considerable variation may exist.

The relation between shape and arrangement of pores is fairly distinct in the genus *Ravenelia*. In the group with equatorial pores the species with the minimum variation between breadth and length has a ratio of 1 : 1.3, or equal to the maximum ratio for the species with scattered pores. The species with bizonate pores are intermediate between the group with scattered pores and the group with equatorial pores. Here the minimum ratio of breadth to length is 1 : 1.2, or equal to the average for the species with scattered pores and below the minimum for the species with equatorial pores. The maximum ratio is 1 : 2.3, a figure exceeding the average ratio for the group with equatorial pores but less than the maximum of 1 : 3.1. Such variability might be expected in a group whose individual species sometimes have pores limited to a bizonate arrangement but which have pores varying between zonate and scattered in other species, as *R. Hoffmanseggiae* and *R. Cassiae-Covesii*. The urediospores of the species with scattered pores are nearly globoid, while the species with equatorial pores are ellipsoid or oblong. This difference is distinct, as Long (29) has noted.

In order to have the data uniform in table 1, the species of *Puccinia* were grouped as those of the other genera. The species were placed in the equatorial-pored group unless the pores were scattered or bizonate and, as a consequence, this group is rather heterogeneous. It is possible to subdivide the equatorial group and to distinguish further variations in shape which seem rather definitely related to the position or the number of the pores.

The group most readily segregated is composed of eight species whose urediospores have the pores arranged in a ring around the hilum. The average urediospore in this group measures  $23.4 \times 23.6 \mu$  and the ratio of breadth to length is 1 : 1. Here the average spore is globoid, but in some species the ratio falls to 1 : 0.88 and the spore becomes broader than high. The species with basal pores are more frequent upon the composites and the mints.

A second group can be segregated on the shape of the spores. The pores are usually two or three and equatorial or slightly be-

low. The spores are oblate-sphaeroid or reniform and usually radially asymmetrical. The average urediospore for the 18 species in this group measures  $24 \times 21 \mu$ , which gives a ratio of breadth to length of only 1 : 0.88. This group of species tends to merge with the group having strictly basal pores and occurs upon the same families of hosts.

A study of the individual ratios of breadth to length for the species of *Puccinia* with equatorial pores indicated that the ratios might be smaller for the species with two pores than for the species with three or more pores. However, after removing the basal-pored and the oblate-sphaeroid groups, the ratios are the same, although the 2-pored species on the composites have a ratio of breadth to length of 1 : 1.18, or less than the average ratio for the species with scattered pores.

The above ratios of breadth to length were obtained from measurements of the urediospores with one pore in face view when the pores are two in number. An examination of the species of *Puccinia* with two pores showed that the spores are usually radially asymmetrical with the pores borne in the flattened sides. Thus, in 20 typically 2-pored species on the Carduaceae the average difference in the two diameters was found to be  $4 \mu$  when the spores were mounted in water and fully expanded. Some of the species, as *P. nuda*, *P. Cyani* and *P. cognata*, have nearly radially symmetrical spores with the diameter with pores in face view only exceeding by  $1 \mu$  that with the pores in side view. On the other hand, a difference of  $6 \mu$  was found for the urediospores of *P. turgidipes*, *P. subdecora*, *P. Balsamorhizae* and others. Such urediospores are decidedly asymmetrical. Thus in *P. Balsamorhizae*, for example, if a line were drawn through the two pores the diameter as measured on that line would be  $21 \mu$ , but if measured on a line at right angles to the pores the diameter would be  $27 \mu$ . Even in species which have symmetrical or nearly symmetrical spores the wall is usually flattened or indented around the pore and the apparent uniform curvature of the wall is due to a cuticular umbo which fills this invagination. In *P. Pluchaeae*, for example, the diameter through the pores is  $25 \mu$  and only  $26 \mu$  in the opposite plane, when the spores are mounted in water, but one-third of the  $25 \mu$  is due to the cuticular umbo. *P.*

*Pluchea* is an extreme example of the kind of spore commonly exhibited by species with only two equatorial pores.

The ratios of breadth to length, given in table 1, are dependable for the urediospores with scattered pores but are misleading for the groups which contain the two-pored species because the differences responsible for the shapes of such spores are three-dimensional.

The preceding data and observations do not lend themselves to concise tabulation. Nevertheless, certain general conclusions seem possible. Radially symmetrical, nearly globoid urediospores are characterized by scattered pores, varying in number from five to ten or more. Urediospores with equatorial pores, usually two to four in number, are ellipsoid or oblong or when seemingly globoid are radially asymmetrical with the pore-bearing sides flattened. Oblate-sphaeroid spores are also radially asymmetrical and show a tendency to have subequatorial or basal pores. Urediospores with bizonate pores are ellipsoid or oblong and tend to have scattered pores when individual spores become more nearly globoid. The pores are usually eight in number.

#### UREDIOSPORE-PORES AND THE PIGMENTATION OF THE WALL

The statements which follow demonstrate that there is a correlation between the arrangement of pores and the pigmentation of the walls of the urediospores. Spores with scattered pores usually have colorless walls while spores with few equatorial pores tend to have strongly pigmented walls.

The Melampsoraceae are characterized by urediospores with little or no color in the walls. In *Melampsora*, especially the autoecious species, some slight coloration is evident and the same is true of *Crossopora*, *Phakopsora* and *Angiopsora*. On the other hand, the urediospores of *Bubakia* are definitely brown and resemble those commonly present in *Puccinia*. The melampsora-ceous rusts are conspicuous by their failure to develop urediospores with equatorial pores. *Bubakia* has equatorial pores, but the position which the genus merits in a natural classification is open to question. It is notable that those genera which are assigned to the Melampsoraceae and whose taxonomic position is

least disputed are those with the least pigment in the walls of the urediospores.

No such uniformity exists in the Pucciniaceae. *Phragmidium* and *Uropyxis* are examples of pucciniaceous genera having urediospores with nearly colorless walls and several scattered pores. On the other hand, the urediospores of *Pileolaria*, *Cumminsiella*, *Tranzschelia*, *Dicheirinia*, *Ravenelia*, *Puccinia*, *Uromyces* and in part those of *Prospodium* show a distinct pigmentation. It is also striking that the species in the genera *Pileolaria*, *Cumminsiella*, *Tranzschelia*, *Dicheirinia* and *Prospodium* have equatorial pores. In *Ravenelia* 26, or 42 per cent, of the species have equatorial pores, while in the combined genera *Puccinia-Uromyces* 75 per cent of the species have equatorial pores. It is also noteworthy that many species of *Puccinia* which have urediospores with nearly colorless walls also have scattered pores, as *P. rubigo-vera*, *P. coronata*, *P. glumarum*, *P. conspicua*, *P. Liatridis*, *P. Eatoniae*, *P. Poae-sudeticae*, *P. Blasdalei*, *P. Oxalidis* and *P. evadens*.

The above statements show that the development of pigment in the walls of urediospores has been rather consistently paralleled by the development of an equatorial rather than a scattered arrangement of pores. There is an accompanying reduction in the number of pores, since the number is less when the pores are equatorial. It seems that an increase in the pigmentation of the walls is a factor in increasing the resistance of spores to adverse climatic conditions.

It is notable in this regard that the walls of teliospores which germinate after overwintering are deeply pigmented, as those of *Melampsora*, *Phragmidium*, *Puccinia* and *Uromyces*. On the other hand, the teliospores of *Coleosporium*, *Mainsia*, *Acrotelium*, *Maravalia* and *Cronartium* have colorless or nearly colorless walls and germinate without an extended period of "rest." There are exceptions in both categories. In the *lepto*-species of *Puccinia* there are often two kinds of teliospores, one pale and capable of immediate germination (*forma persistens*), the other darker and capable of overwintering (*forma fragilipes*). Dietel (14) and Jørstað (27) have discussed such species.

Present information indicates that pigmentation of the walls of

aeciospores is also associated with an increased ability to remain viable during exposure to climatic extremes. The studies by Fukushi (20) with *Gymnosporangium Yamadae* and by Miller (30) with *G. Juniperi-virginianae* prove that the pigmented spores of these two species are more resistant to exposure than are the paler spores of *G. Ilaraeum* (20).

Published data regarding the longevity of urediospores are conflicting but one paper indicates that the pigmentation of the walls of urediospores serves in a protective capacity. By using the color mutants discovered by Newton and Johnson (32) in *Puccinia graminis Triticis*, Dillon Weston (18) proved that the normally pigmented walls are more resistant to ultra-violet radiation than are the mutants lacking the pigment.

Species which develop amphispores in addition to ordinary urediospores offer further examples indicating that pigmentation serves in a protective capacity. The amphispores are more deeply pigmented than the urediospores in such species and often have fewer pores. For example, the urediospores of *Puccinia vexans* have several scattered pores while the amphispores have three or four equatorial pores. Urediospores and teliospores are not formed in abundance in amphisporic rusts, the amphispores serving to preserve the species through the winter, as Carleton (11) proved experimentally with *P. vexans*. Amphisporic species are probably capable of existing independent of an alternate host for indefinite periods. The amphispore, an adaptive modification of an urediospore, makes this possible.

The evident changes which have given rise to amphispores have been a thickening of the wall, an increase in pigmentation and often a decrease in the number of pores. Since amphispores have persistent pedicels their importance as disseminating agents has become secondary, and they have assumed one of the functions and some of the morphology of teliospores. Urediospores which have the same pigmentation of the walls but which have retained easily disjoined pedicels must also have increased their chance of survival, but without diminishing their capabilities for dissemination.



## UREDIOspore-Pores AND UREDIAL PERIDIA AND PARAPHYSES

The presence of peridia or paraphyses is characteristic of the uredia of many species, and is correlated with the scattered arrangement of pores in the urediospores. It was pointed out above that the Melampsoraceae have urediospores with several scattered pores and unpigmented walls. The formation of a peridium is also a development common to most of these rusts. Thus a peridium is present in *Uredinopsis*, *Milesia*, *Hyalopsora*, *Melampsoridium*, *Pucciniastrum*, *Cronartium* and *Chrysomyxa*. The species of *Melampsora* are conspicuous for the development of numerous paraphyses, while in *Phakopsora* the uredia may have paraphyses or these may be united at their base to form a peridium. Neither peridia nor paraphyses are present in *Coleosporium*. They also are wanting in *Bubakia*, but as indicated before this genus deviates from other genera of the Melampsoraceae.

A peridium, as formed in the Melampsoraceae, is no longer present in the Pucciniaceae and, while paraphyses characterize certain genera, a majority of the species of the family have neither. A change in the arrangement of the pores from scattered to equatorial has occurred more or less in parallel with the elimination of peridia and paraphyses.

Paraphyses are present in all of the species of *Tranzschelia* and *Phragmidium*, in most of the species of *Uropyxis*, *Dicheirinia* and *Prospodium*, in about one-third of the species of *Ravenelia* and *Cumminsiella*, in a minority of the species of *Puccinia* and *Uromyces* and in none of the species of *Pileolaria*. The species of *Phragmidium* and *Uropyxis* have urediospores with scattered pores. The pores are equatorial in *Tranzschelia*, *Dicheirinia*, *Prospodium* and *Pileolaria* and equatorial or bizonate in *Cumminsiella*. Of the species of *Ravenelia* studied 20 of 28 (71 per cent) which have scattered pores also have paraphyses, 16 of 26 (61 per cent) which have equatorial pores have paraphyses, and 6 of 8 (75 per cent) which have bizonate pores also have paraphyses. In the genus *Puccinia* 20 species were found to have paraphyses. Of this 20, 65 per cent have urediospores with scattered pores and the species occur almost exclusively upon the grasses.

This summary again serves to emphasize that the urediospores and their sori have experienced a parallel evolution. It is significant that the more primitive genera have retained peridia or paraphyses, which probably serve a protective function according to Dietel (15), Arthur *et al* (3) and Grove (21), but that in the more advanced genera, especially *Puccinia*, these structures have been all but eliminated. It is also significant that most of the urediospores developed in these protected sori have scattered pores and colorless or nearly colorless walls.

Such a consistent trend indicates that the retention of protective structures in the sorus became unnecessary as the pigment in the walls increased and the number of pores decreased. Or it may be that the loss of protective structures came first and that those species survived which compensated this loss by the development of urediospores with more pigment and with fewer pores.

The change from a peridium to paraphyses is more or less paralleled by an increase in the length of the pedicels of the urediospores. A peridium is well developed in the *Pucciniastreae* and the urediospores are nearly sessile. Where paraphyses are present but the peridial tissue absent, as in *Ravenelia* and *Puccinia*, the urediospores have definite, well differentiated pedicels. This parallelism is to be expected since peridial cells and paraphyses are metamorphosed spore-initials. As the urediospores develop pedicels the tendency is also toward the production of stipitate paraphyses rather than a cellular peridium.

#### UREDIOSPORE-PORES AND THEIR RELATION TO OTHER CHARACTERISTICS OF THE RUSTS

The data in preceding sections show rather clearly that several scattered pores is a condition characteristic of the urediospores of the more primitive genera and that urediospores with few equatorial pores increase in frequency in the more advanced genera. The following data demonstrate that the scattered arrangement of pores is also correlated with other characters generally conceded to be primitive.

Because of the large number of species and the diversity of life cycles and of hosts the following data deal mainly with *Puccinia*

and *Uromyces*, with reference made to other genera when pertinent to the discussion. Since *Puccinia* and *Uromyces* are retained as separate genera only for convenience they were merged in compiling most of the data. Only species with uredia are considered.

THE RELATION OF POSITION OF UREDIOSPORE-PORES TO  
HETEROECISM AND AUTOECISM

A study of the species of *Puccinia-Uromyces* of known life cycle shows that a relationship exists between the arrangement of the pores in the urediospores and heteroecism and autoecism. The data are given in table 2.

TABLE 2

THE RELATION OF NUMBER AND ARRANGEMENT OF PORES IN THE  
UREDIOSPORES TO HETEROECISM AND AUTOECISM IN  
*Puccinia-Uromyces*

Arrangement of pores	Heteroecious		Autoecious	
	Species	Per cent	Species	Per cent
Scattered .....	37	43	35	18
Equatorial .....	49	57	162	82
Pores 3+ .....	32	65	84	52
Pores 2 .....	16	33	76	47
Pores 1 .....	1	2	2	1

The data in table 2 demonstrate that the scattered arrangement of pores is possessed more frequently by heteroecious species than by autoecious species, and that a marked majority (82 per cent) of the autoecious species have equatorial pores. Since pores when equatorial are usually fewer in number than when scattered, it follows that autoecious species tend to have fewer pores in the urediospores than do heteroecious species. It should also be noted that a greater proportion of the heteroecious species with equatorial pores have three or more pores than do the autoecious species.

Although some of the autoecious genera of the Pucciniaceae (*Uropyxis*, *Phragmopyxis* and *Phragmidium*) have urediospores with scattered pores only, it is notable that the species of the Melampsoraceae are heteroecious and that none have equatorial

pores except *Ilyalopsis* and *Bubakia*, the latter with life cycle unknown.

This analysis shows that the change in the arrangement of the pores in urediospores tends to parallel the change from heteroecism to autoecism, in that the scattered arrangement is more common in heteroecious than in autoecious species. Since heteroecism is usually believed to be a more primitive condition than autoecism [Blackman (9), Arthur (1), Orton (33), Jackson (26)] it is evident that urediospores with scattered pores are significantly associated with the more primitive type of life cycle.

#### THE RELATION OF POSITION OF UREDIOSPORE-PORES TO AECIA

A considerable number of the species of *Puccinia-Uromyces* have uredinoid rather than aecidioid aecia and a tabulation of the species demonstrates that there is a correlation between the arrangement of the pores in the urediospores and the kind of aecia. A greater proportion of the species with aecidioid than with uredinoid aecia have scattered pores. Only species of known life cycle are used. The data are given in table 3.

TABLE 3

THE RELATION OF NUMBER AND ARRANGEMENT OF PORES IN THE UREDIOSPORES TO THE AECIA IN *Puccinia-Uromyces*

Arrangement of pores	Aecia aecidioid		Aecia uredinoid	
	Species	Per cent	Species	Per cent
Scattered.....	67	32	5	7
Equatorial.....	143	68	68	93
Pores 3+.....	82	57	34	50
Pores 2.....	59	41	33	49
Pores 1.....	2	2	1	1

The data in table 3 show that the change in the arrangement of the pores in the urediospores has rather closely paralleled a change in the aecia. Urediospores with scattered pores and aecia that are aecidioid are more often associated than are scattered pores and uredinoid aecia, while 93 per cent of the species with uredinoid aecia have urediospores with equatorial pores. A study of the species which have three or more equatorial pores or only

two equatorial pores gives little that is significant (table 3). The differences are too small to allow the prediction that species with uredinoid aecia and equatorial pores tend toward a reduction in the number of pores.

With the preceding results in mind a study was made of the distribution of species having the various arrangements of pores, according to whether the species are heteroecious with aecidioid aecia, or autoecious with aecidioid or uredinoid aecia. No known heteroecious species has uredinoid aecia. The results are given in table 4.

TABLE 4

THE DISTRIBUTION OF SPECIES OF *Puccinia-Uromyces* ACCORDING TO THE AECIA, HETEROECISM, AUTOECISM AND ARRANGEMENT OF PORES IN THE UREDIOSPORES

Arrangement of pores	Heteroecious			Autoecious			
	Aecidioid		Uredinoid	Aecidioid		Uredinoid	
	Species	Per cent		Species	Per cent	Species	Per cent
Scattered.....	37	43	0	30	24	5	7
Equatorial.....	49	57	0	94	76	68	93
Pores 3+.....	32	65	0	50	53	34	50
Pores 2.....	16	33	0	43	46	33	49
Pores 1.....	1	2	0	1	1	1	1

The data in table 4 show that species which have urediospores with scattered pores are more commonly heteroecious than autoecious, and more commonly have aecidioid than uredinoid aecia. Species with equatorial pores are autoecious more commonly than heteroecious. Although more species have aecidioid than uredinoid aecia, yet a greater proportion of those with uredinoid aecia have urediospores with equatorial pores than do those with aecidioid aecia. In the last three lines of table 4 the equatorial group is divided into subgroups, as in tables 2 and 3. The differences are not great but show a consistent trend, in that there seems to be some tendency toward a decrease in the number of pores as the life cycle changes from heteroecious to autoecious and the aecia from aecidioid to uredinoid.

Unfortunately the life cycles of the species of *Ravenelia* are too poorly understood to offer substantial evidence on this point.

It is known that the aecia may be aecidioid or uredinoid, according to the species considered, and perhaps most have uredinoid aecia. The aecia are uredinoid in the genus *Uropyxis* and the pores in the urediospores are scattered. On the other hand, uredinoid aecia occur in *Dicheirinia*, *Maravalia*, *Pileolaria*, *Uromycladium*, *Prospodium*, *Mainsia*, *Kuehneola*, and probably *Hyalophragmium* and *Sphaerophragmium*, all genera having urediospores with few equatorial pores in most and perhaps in all species. There are no species known to have uredinoid aecia in the Melampsoraceae and none have equatorial pores, except *Bubakia* and some species of *Hyalopsora*.

Jackson (26) has presented evidence that aecidioid aecia are more primitive than uredinoid aecia, a belief previously implied in Arthur's (2) life cycle classification. The relationship, shown in tables 3 and 4 between urediospores with scattered pores and aecidioid aecia, again demonstrates that the scattered arrangement of pores tends to be significantly correlated with primitive characters. The opposed, or equatorial arrangement, is almost exclusively present in species having the more recent uredinoid type of aecium.

#### UREDIOSPORE-PORES AND ARTHUR'S CLASSIFICATION OF PUCCINIA- UROMYCES

In addition to the preceding data Arthur's (4) classification of *Puccinia-Uromyces* is important. He has made the only attempt, based upon a large flora, to separate the species into phylogenetic groups. The separation is based partly upon the kind of aecia but more especially upon the morphology of the teliospores. Arthur considers the section *Eupuccinia* to contain the more primitive species and the section *Bullaria* the more recent species.

Arthur's (4) Manual contains 304 species of *Puccinia-Uromyces* which have uredia. A tabulation of the two sections shows that 71 of the 202 species in *Eupuccinia* have scattered pores and that 131 have equatorial pores, or 35 per cent and 65 per cent, respectively. Similar tabulation of the section *Bullaria* shows that 20, or 20 per cent, of the 102 species have urediospores with scattered pores while 82, or 80 per cent, have equatorial pores.

Since Arthur's classification is based upon the morphology of

the teliospores it is evident that the arrangement of the pores in the urediospores of *Puccinia-Uromyces* tends to change in parallel with changes in the morphology of the teliospores. Urediospores with several scattered pores are most often associated with teliospores which are oblong, have smooth, apically thickened walls, persistent pedicels and the pore of the lower cell at the septum (§ *Eupuccinia*). Urediospores with few equatorial pores are most often associated with teliospores which are ellipsoid, have sculptured, uniformly thickened walls, fragile pedicels and the pore of the lower cell tending toward the pedicel (§ *Bullaria*). In other words, urediospores with scattered pores tend to be associated with primitive teliospores.

#### THE RELATION OF POSITION OF UREDIOSPORE-PORES TO HOSTS

Having found that the arrangement of pores in the urediospores is related to heteroecism, autoecism and the aecia, figures were compiled which demonstrate that there is a general correlation with the groups of hosts. The data are presented in table 5 and are based upon species of *Puccinia* with known life cycles.

TABLE 5

THE RELATION OF THE ARRANGEMENT OF UREDIOSPORE-PORES IN  
THE GENUS *Puccinia* TO THE GROUPS OF HOSTS

Hosts	Aecia aecidioid				Aecia uredinoid			
	Scattered		Equatorial		Scattered		Equatorial	
	Species	Per cent	Species	Per cent	Species	Per cent	Species	Per cent
Monocots . . . . .	34	46	40	54	0	0	0	0
Dicots . . . . .	10	14	64	86	4	6	61	94
Archichl. . . . .	5	23	17	77	3	16	16	84
Metachl. . . . .	5	10	47	90	1	2	45	98

A definite relationship apparently exists here (table 5), and since the data in table 3 proved that the species of *Puccinia-Uromyces* with uredinoid aecia show a preponderance of urediospores with equatorial pores over those with aecidioid aecia, it becomes apparent that the proportion of species with scattered pores is greater on the monocotyledonous hosts. Not only has a

greater proportion of the species of *Puccinia* on the Dicotyledoneae developed equatorial pores but the two subgroups within the dicotyledons differ in this respect. The species on the Metachlamydeae considerably exceed those on the Archichlamydeae and, in those with uredinoid aecia, comprise 98 per cent of the species.

A segregation of the data providing the basis for table 5, to account for heteroecism and autoecism, brings out further interesting figures, which are given in table 6.

TABLE 6  
THE RELATION OF HETEROECISM, AUTOECISM AND ARRANGEMENT OF PORES IN THE UREDIOSPORES TO THE MAJOR GROUPS OF HOSTS FOR THE GENUS *Puccinia*

Hosts	Pores scattered				Pores equatorial			
	Heteroecious		Autoecious		Heteroecious		Autoecious	
	Species	Per cent	Species	Per cent	Species	Per cent	Species	Per cent
Monocots.....	27	79	7	21	35	87	5	13
Dicots.....	3	21	11	79	2	2	123	98
Archichl....	3	38	5	62	2	6	31	94
Metachl....	0	0	6	100	0	0	92	100

The data in table 6 show that the species of *Puccinia* on the monocotyledons are more apt to be heteroecious than autoecious, while those on the dicotyledons are more apt to be autoecious than heteroecious. Likewise, the species on the Archichlamydeae are more apt to be heteroecious than are those on the Metachlamydeae.

A total of 213 species is included in table 6, 74 on the monocotyledons and 139 on the dicotyledons. Of those on the monocotyledons 54 per cent have equatorial pores, but the pores are equatorial in 90 per cent of the species on the dicotyledons. Likewise, 80 per cent of the species on the Archichlamydeae have equatorial pores while the pores are equatorial in 94 per cent of the species on the Metachlamydeae.

Arranging the grass rusts of North America according to the system of tribes in the Poaceae, as presented by Hitchcock (23), shows that a more or less consistent trend exists among the grass



rusts, *Puccinia-Uromyces*. Species with scattered pores are more frequent on the primitive tribes and decrease in abundance on the advanced tribes. Species with equatorial pores are rare on the primitive tribes and more numerous on the higher tribes. This is shown graphically in figure 1.

Grass tribe	Pores equatorial	Pores scattered
Bamboseae.....	xxx	
Festuceae.....	xxx	xxxxxxxxxxxxxxxxxxxxxx
Hordeae.....	x	xxxxxxxx
Aveneae.....	x	xxxxxxxx
Agrostideae.....	xxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxx
Nazieae.....		xxx
Chlorideae.....	xxxxxx	xxxxxxxxxx
Phalarideae.....	x	xx
Oryzeae.....	x	
Paniceae.....	xxxxxxxxxxxxxxxxxxx	xxxxxx
Andropogoneae.....	xxxxxxx	xxxxx
Tripsaceae.....	xxxxx	

Fig. 1. The relation between the arrangement of urediospore-pores and the host tribes for the North American grass rusts, *Puccinia-Uromyces*. Each x represents one species.

The above data show that there is a general correlation, in the genera *Puccinia* and *Uromyces*, between the arrangement of the pores in the urediospores and the taxonomic position of the hosts parasitized. Species with scattered pores are more frequent on the Archichlamydeae than on the more advanced Metachlamydeae and more frequent on the primitive than on the advanced tribes of the grasses. A greater proportion of the species on the Monocotyledoneae than on the Dicotyledoneae have scattered pores and, since the Monocotyledoneae are thought to have been derived from the Dicotyledoneae (see Hutchinson, 25), the general correlation does not hold with respect to the species on the monocotyledons.

#### DISCUSSION AND CONCLUSIONS

The differences which exist between the uredia and urediospores of the Melampsoraceae and the Pucciniaceae have been reviewed in some detail. The melampsoraceous species have uredia with peridia or paraphyses and urediospores with colorless or nearly colorless walls and several scattered pores. Exceptions were pointed out. The Pucciniaceae have uredia with no peridia

and in the majority of species with no paraphyses. While diverse in the various genera and species the walls of the urediospores are usually pigmented and provided, in a consistent majority, with few equatorial pores. The species which have paraphyses more commonly have spores with scattered pores and colorless wall than with equatorial pores and a pigmented wall. A specialization in the shape of urediospores with equatorial pores also was indicated. Correlations were shown to exist between the scattered arrangement of urediospores and heteroecism and aecidioid aecia, and between equatorial pores and autoecism and uredinoid aecia. Primitive teliospores in *Puccinia* and *Uromyces* are more apt to be associated with urediospores with scattered than with equatorial pores. Moreover, the primitive groups of hosts support a greater proportion of species with scattered than with equatorial pores while the advanced groups of hosts support a preponderance of species with equatorial pores.

Such a consistent association of the scattered arrangement of pores with other characters conceded to be primitive leads to the conclusion that *several scattered pores represent the primitive condition for urediospores*. Otherwise one is reduced to considering that the evolution of the uredia and their spores has proceeded independently of the evolution of species. Since the evolutionary sequence of genera and species can only be decided by changing morphology the two cannot well be divorced.

If one chooses to base interpretations upon telia only, one cannot avoid recognizing parallel development, since urediospores with scattered pores and colorless walls, and uredia with peridia or paraphyses occur in the genera which have teliospores in laterally adherent crusts. Even the species of *Puccinia* which have indehiscent, compact telia also commonly have urediospores with scattered pores, as *P. coronata*, *P. Eatoniae*, *P. Koeleriae*, *P. Liatridis*, *P. glumarum*, *P. Hordei*, *P. anomala*, *P. Blasdalei*, *P. Porri*, *P. granulisporea* and *P. subangulata*. Some of these species also have uredial paraphyses and, so far as known, all are heteroecious except the last four.

Aside from the change from several scattered pores to few equatorial pores there is evidence that the tendency to reduce the number of pores is continued within the equatorial-pored species

of *Puccinia-Uromyces*. The data in table 2 show that a greater proportion of the heteroecious than of the autoecious species have three or more pores. Following table 3 it was pointed out that more of the species with aecidioid aecia have three or more pores than do the species with uredinoid aecia. Furthermore, table 4 shows that the proportion of three-pored species decreases from a maximum in the heteroecious aecidioid group through the autoecious aecidioid group to its minimum in the autoecious uredinoid group. Although the differences are not great the trend appears to be consistently toward fewer pores.

It was pointed out that the arrangement of the pores in urediospores tends to change with the changing morphology of the teliospores in *Puccinia-Uromyces*. Nevertheless, some species whose telia indicate recent development have retained uredia and urediospores of the primitive type. No species is more anomalous than *Puccinia paradoxica*. This rust has specialized teliospores, typical of Arthur's section *Bullaria*, yet the uredia have paraphyses and the urediospores have scattered pores and a nearly colorless wall. The complete life cycle is not known. Species with such teliospores are usually autoecious but there are exceptions, as *P. Bistortae*. Some species of *Uromyces* on fabaceous hosts also have *Bullaria*-like teliospores but urediospores with scattered pores, and are heteroecious, as *U. occidentalis* and *U. punctatus*. While these species have teliospores of a specialized type they have retained the more primitive life cycle and arrangement of pores in the urediospores.

There are also autoecious species with teliospores of the primitive type of Arthur's section *Eupuccinia* but with urediospores having two equatorial pores. *Puccinia Helianthi* is a common species of this kind. *P. Helianthi*, however, appears to be of unstable life cycle and sometimes forms pycnia and aecidioid aecia but occasionally has pycnia associated with uredia (uredinoid aecia), as discovered by Carleton (11) and verified by Bailey (7). In addition to having urediospores with two equatorial pores the species seems then, also to be tending toward a change from aecidioid to uredinoid aecia. Jackson (26) has pointed out that the autoecious *Puccinia orbicula* likewise has an unstable life cycle, with pycnia and aecidioid aecia sometimes associated or

with pycnia occurring with the uredia in other cases. While the teliospores of *P. orbicula* are typical of the section *Bullaria* the pores of the urediospores are not equatorial. Nevertheless, the number of pores is variable, sometimes only two or three, and the urediospores seem unstable as well as the aecia.

While not all morphologic characters change strictly in parallel the tendency in *Puccinia* seems to be toward parallel changes which would ultimately yield autoecious species with uredinoid aecia, teliospores with uniformly thick, sculptured walls, fragile pedicels (and perhaps with the pore of the lower cell near the pedicel) and urediospores with few equatorial pores, provided that the aecia and uredia are not eliminated during the course of evolution. This appears to happen with increasing frequency as this theoretically ultimate morphology is approached, as is pointed out below.

It is interesting to note that Hutchinson (24), in stating the "general principles adopted for the classification of plants," includes as his first three dicta rules which apply to the rusts. The three dicta are: (1) evolution is both upwards and downwards, the latter involving degradation and degeneration; (2) evolution does not necessarily involve all organs of the plant at the same time, and one organ or set of organs may be advancing whilst another set is stationary or retrograding; (3) evolution has generally been consistent, and when a particular progression or retrogression has set in, it is persisted in to the end of the phylum.

It is probable, because of the strict parasitism of the rusts, that evolution has generally been toward simplification rather than toward amplification, as evidenced by the simplification of life cycles, reduction in the number of pores in the urediospores and loss of uredial paraphyses, and perhaps upward through the production of a protective coloration and greater adaptation for dissemination. Kern (28) and Orton (33) have pointed out that parasitism may account for the tendency toward simplification of life cycles. It has been mentioned in this paper that evolution has not involved all characters at the same time, but it was also pointed out that the changes in the pores of the urediospores and other features peculiar to the sorus and its spores have been remarkably consistent.

There is also evidence that the changes in the morphology of the teliospores, which were discussed above, have followed through the genera *Puccinia* and *Uromyces* consistently, and that the changes have been paralleled by a progressive simplification of the life cycle. For example, in the section *Eupuccinia*, less than one-third (85 species = 29 + per cent) of the species have lost the uredia or the aecia or both, but in the section *Bullaria* one-half (98 species = 49 + per cent) of the species have become demicyclic or microcyclic.

Data presented in tables 5 and 6 indicate that the monocotyledons have remained a more primitive group than the dicotyledons. Although questions of phylogeny are open to controversy the view that the monocotyledons are more primitive than the dicotyledons does not have the support of phanerogamic taxonomists (see Hutchinson, 25). However, it is not so much a question of whether the monocotyledons have been derived from the dicotyledons as of which of the two groups has progressed the farther from the original type. In other words, while the monocotyledons may have been derived from the lower orders of the dicotyledons, they may still contain fewer recently developed orders and families than the dicotyledons. The important factor here is the relative ages of the various hosts, rather than the point of origin of the two major groups. It would be strange if the otherwise consistent trends brought out in this paper should fail only with respect to the monocotyledonous hosts. It is not the purpose of this paper to question the phylogeny of the angiosperms but it is permissible to follow to its logical conclusions the theory that the scattered arrangement of several pores is the primitive condition for urediospores. On that basis the conclusion is justified that the species of *Puccinia-Uromyces* which inhabit the monocotyledons are more primitive, on the whole, than are those which inhabit the dicotyledons.

Even though the morphologic characters of the rusts change more or less in parallel, the variability is still such that it is difficult to choose characters of taxonomic value, although the differences, or more correctly the similarities, in morphology furnish the evidence upon which relationships are based. Classifications are based primarily upon the telia and teliospores, and correctly

so, but a natural system cannot be attained with the use of a single spore-form. For that reason the present study should aid in reaching a more natural grouping, which is the major aim of taxonomic work. While no attempt has been made to construct a natural classification the application of the data in this paper may indicate the relationship of genera and species to some extent.

Beginning with the Melampsoraceae it is logical to consider that the Pucciniastreae represent a closely related group of genera, since all have uredia and urediospores with similar characters; all have peridia and a like arrangement of pores. This relationship has not been doubted. *Melampsora* shows relationship to the Pucciniastreae through the species on *Salix* and has probably given rise in turn, through the autoecious species with slightly pigmented urediospores, to *Bubakia*, which represents the highest development of the Melampsoraceae.

Although *Crossopsora* is usually thought to be closely related to *Cronartium* this seems unlikely, since the uredia have paraphyses rather than peridia and the urediospores have equatorial pores and pigmented walls. The shape of the spores is rather specialized in some species of *Crossopsora*, which is not true of *Cronartium*. It is probable that, while the telia have developed in parallel, the genera may have little direct relationship.

Within the Pucciniaceae uredia may be used as an index of relationships in some cases. For example, *Ravenelia* appears to have served as a point of origin for several smaller genera which have urediospores of specialized shape and sculpture and few, often one or two, equatorial or basal pores. These genera are *Sphaerophragmium*, *Hapalophragmium*, *Dicheirinia*, *Diorchidium* and *Uromycladium*. I consider that these genera are derivatives of *Ravenelia* rather than the reverse, as Dietel's (17) classification implies, because all of them have urediospores with equatorial pores. Other features, such as the reduction in the complexity of the teliospore-heads, likewise favor this arrangement.

*Dicheirinia*, *Hapalophragmium* and *Sphaerophragmium* have characteristic, radially asymmetrical urediospores so similar that the genera can be separated accurately only with the aid of telial characters. The urediospores of these three genera indicate a closer relationship to *Ravenelia* than to *Uromycladium*. The

sculpturing of the walls and the arrangement of the pores in the urediospores of *Uromycladium* is so similar to that of *Pileolaria*, on the other hand, as to indicate a relationship, especially through such a species as *P. phyllodiorum*, as Dietel (16) has suggested. Although a relatively unknown genus, *Maravalia* is evidently related to *Pileolaria* and *Uromycladium*. Dietel (17) states that the urediospores are spindle form and warted in *M. hyalospora* and I have found (in *M. utriculata* Syd.?) that the aecia are uredinoid with striately sculptured aeciospores having equatorial pores, and that the pycnia are subcuticular. These are characters also found in *Pileolaria*.

Since classifications of single genera usually follow the families of hosts the relationship of species is often obscured. This is desirable for convenience but makes the arrangement of species artificial. In the genus *Puccinia*, for example, the species on grasses are arranged according to the genus or tribe (often alphabetically) which serves as the telial host. This often separates species having common characters, as *P. pygmaea*, *P. coronata*, *P. Eatoniae*, *P. Koeleriae*, *P. Liatridis*, *P. conspicua*, *P. Poae-sudeticae*, *P. Piperi*, *P. procera*, *P. montanensis*, *P. rubigo-vera*, *P. glumarum*, *P. Hordei*, *P. anomala*, *P. sessilis*, *P. Cockerelliana* and *P. Poarum*, all species having urediospores with only slightly pigmented walls and several scattered pores, and several of which have uredial paraphyses. The telia are also similar, being indehiscent and paraphysate with teliospores with short pedicels, a wall not greatly thickened apically and often paler in color than those in dehiscent exposed telia. If Arthur (4) had followed more closely the arrangement of the grass tribes presented by Hitchcock (23) the sequence of the species of *Puccinia-Uromyces* would correspond more closely to their relationships. The species with nearly colorless urediospores with scattered pores and with indehiscent telia would start the sequence and gradually be replaced by species with pigmented, equatorial-pored urediospores and erumpent dehiscent telia. This was demonstrated in figure 1 with respect to the arrangement of pores.

The rusts on the Cyperaceae are a relatively homogeneous group with a tendency toward urediospores with superequatorial pores and an almost complete absence of species with scattered

pores (*P. karelica*). These characters set them off rather sharply from the rusts on grasses and indicate a relationship with the rusts on Juncaceae.

Although such groups of species as those mentioned above appear to be interrelated there is a practical limit to the number of sections into which a genus can be divided without creating confusion, thereby defeating the primary purpose of such subdivisions, *i.e.*, to indicate relationships.

It is open to question in how far the use of urediospores or uredia is justified in classifications. It seems probable that they may furnish the characters by which certain genera, as *Cerotelium* and *Kuehneola*, *Cronartium* and *Crossopsora* for example, can be satisfactorily distinguished. However, the segregation or aggregation of species according to the arrangement of the pores in the urediospores can only be advantageous when other morphologic features are also considered.

An attempt to construct a classification including all genera and giving due consideration to the uredia and their spores will provide the real test of the data presented in this paper. This, to be successful, must await more complete information regarding many poorly understood genera, and would be aided by studies, similar to the present one, in other regions and on other morphologic characters. A system to be of phylogenetic significance should be based upon entire plants, and the more complete the available information the better the system will be.

#### SUMMARY

1. The data presented in this paper clearly indicate that the scattered arrangement of several pores is the primitive condition for urediospores, since such spores are: (1) commoner in the Melampsoraceae than in the Pucciniaceae, (2) not specialized in shape, (3) usually provided with colorless or nearly colorless walls, (4) commonly produced in uredia having peridia or paraphyses, (5) significantly associated, in *Puccinia-Uromyces*, with heteroecism, aecidioid aecia and primitive teliospores, and (6) tend to predominate on the more primitive groups of hosts of the genera *Puccinia* and *Uromyces*. The equatorial arrangement of few pores is correlated with the opposed character in each of the



above categories, which indicates that it is an advanced character, phylogenetically.

2. There is no evidence indicating that these changes have been detrimental, and the decrease in the number of pores and the increase in pigmentation are believed to increase the longevity of the spores. It is also suggested that the loss of uredial peridia and paraphyses, believed by previous writers to be protective structures, has been compensated by the development of urediospores with pigmented walls and fewer pores.

3. The present tendency in *Puccinia-Uromyces* appears to be toward parallel changes which would ultimately yield autoecious species with uredinoid aecia, urediospores with few equatorial pores, and teliospores with uniformly thick, sculptured walls and fragile pedicels. The aecia and uredia have been eliminated with increasing frequency as this theoretically ultimate morphology has been approached.

4. Judged on the basis of the arrangement of urediospore-pores the Pucciniastreae appears to be a closely related group of genera which has probably given rise to *Melampsora* and *Bubakia*. *Crossopora* and *Cronartium* do not seem to be as closely related as usually assumed. It is likely that *Ravenelia* has given rise to *Sphaerophragmium*, *Hapalophragmium*, *Dicheirinia*, *Diorchidium* and *Uromycladium*, rather than the reverse, while *Uromycladium* appears to be the parent stock for *Pileolaria* and *Maravalia*. Within the grass rusts of the genera *Puccinia* and *Uromyces* a natural arrangement would begin with species having nearly colorless urediospores with scattered pores and indehiscent telia and gradually extend to species having such advanced characters as pigmented, equatorial pored urediospores and erumpent dehiscent telia.

5. The data are in agreement with the general belief that evolution in the rusts has been toward simplification and reduction.

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# CELL RELATIONS IN THE PERITHECIUM OF *CERATOSTOMELLA MULTIANNULATA*

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(WITH 75 FIGURES)

## INTRODUCTION AND HISTORICAL REVIEW

Included in the Ascomycetae are genera in which the asci are developed from isolated free cells, from a fusion of two cells, or within various types of organized fruiting bodies. The latter are commonly distinguished as open (apothecial) or closed (perithecial), although there exist many compound and elaborately constructed variations of the open and closed types of development. The complete history of cell behavior preceding ascus formation is known in a comparatively few species of the apothecial type and in a still smaller number of those in which asci are borne in perithecia. *Ceratostomella multiannulata* Hedgcock and Davidson (9) is an especially favorable species for the study of a type of perithecial development first described by Mittmann (20) in *C. fimbriata* (E. & H.) Elliott, in which ascus formation is preceded by an extensive multiplication of independent and un-walled cells (FIG. 1). A separate paper has been devoted to the structure and development of the ascus in two related species (2); in the present communication greater emphasis will be placed on those proliferative stages preceding ascus formation which may be referred to as the development of the ascogenous system.

Since the earliest studies on structure and development in the ascomycetous fungi evidence has existed tending to show that the processes leading to ascus formation in those species with an organized fruiting body may follow fundamentally different courses. The convincing work of Harper and his students led to greater emphasis being directed to that course of development, represented by *Pyronema* and discomycetous species in general, wherein asci are produced following a characteristic crosier device either terminally or laterally on hyphae that are direct outgrowths from an oögonium or group of ascogonial cells. The few recent

investigators in this field who ventured outside the group of discomycetous species have been inclined to interpret their findings in accordance with the above process, even though it were not possible in some cases to follow the various stages intermediate between ascogonium and ascus. This applies in part to the work of Elliott (11) and Varitchak (24) on *Ceratostomella*,

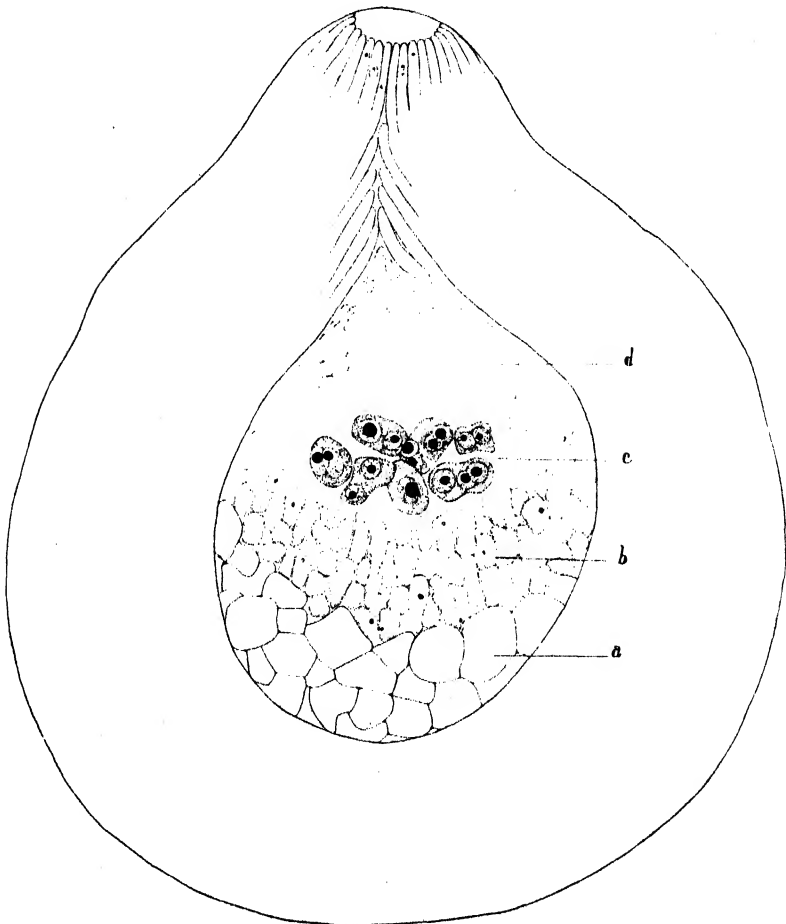


FIG. 1. Diagram showing the interior organization of the perithecium of *Ceratostomella multiannulata* at the beginning of beak formation; *a*, pseudo-parenchyma of thin-walled cells; *b*, uninucleate nutritive or space-making cells; *c*, the actively dividing binucleate fertile or ascogenous cells; *d*, a mostly vacant space, but containing disorganized cells at the point where the ostiole will be formed.  $\times 1500$ .

of Cookson (8) on *Melanospora*, and in fact to most of the more recent work on species of so-called Pyrenomycetes. Other investigators, unable to follow the stages intermediate between ascogonium and asci, have concluded that the ascogonium is abortive and that ascogenous hyphae later grow out from purely vegetative cells within the perithecium. A review of early literature in this field has been made by Overton (23).

The contribution of Moreau (21) concerning *Peckiella lateritia* (Fries) Maire illustrates the tendency of a few investigators to speak of ascogenous hyphae although they are unable to demonstrate the existence of true hyphal growths. Crosiers occur in *P. lateritia*, yet the illustrations shown indicate that each crosier, or each parent cell, is an independent unit free of any hyphal base. Fraser and Chambers (12) state that in *Aspergillus herbariorum* Wiggers "the ascogonium becomes septate and each of its cells gives rise to ascogenous hyphae," although their illustrations do not demonstrate clearly the hyphal outgrowths from the ascogonium. The "outgrowths" appear to be single cells that may, either directly or after a crosier type of cell division, develop into asci.

Blackman and Welsford (5) described a much-coiled and septate ascogonium in *Polystigma rubrum* D.C. but they considered it to be abortive—ascogenous hyphae developing later from purely vegetative cells within the perithecium. Cayley (7) reached much the same conclusion in regard to *Nectria galligena* Bres. McIntosh (19) considered the hyphal outgrowths from ascogonia of *Nectria mammoidea* to be abortive structures. He says: "The true ascogenous hyphae arise directly from the vegetative cells at the foot of the cavity. These hyphae consist of a single cell which is generally binucleate."

With respect to some of the above accounts it is pertinent to question whether or not a single cell of the type described can be properly called an ascogenous hypha, and whether the ascogenous cells are true outgrowths or simply fragments resulting from a division of the oögonium. Questions of this nature are raised especially by what has been learned of cell relations in *Ceratostomella*.

A few investigators have recognized that individual cells of

the ascogonium may become separated and proliferate independently. Brown (6) observed such to be the case in *Xylaria tentacularia* B. & Br., and Lupo (17) in *Hypoxyylon coccineum*. Varitchak (24) illustrated a similar condition in *X. polymorpha* (Pers.) Grev. The several independent fragments of the ascogonium proliferate presumably by means of ascogenous hyphae. This type of development would seem to be somewhat intermediate between the discomycetous type and that which is now known to occur in the Ceratostomataceae.

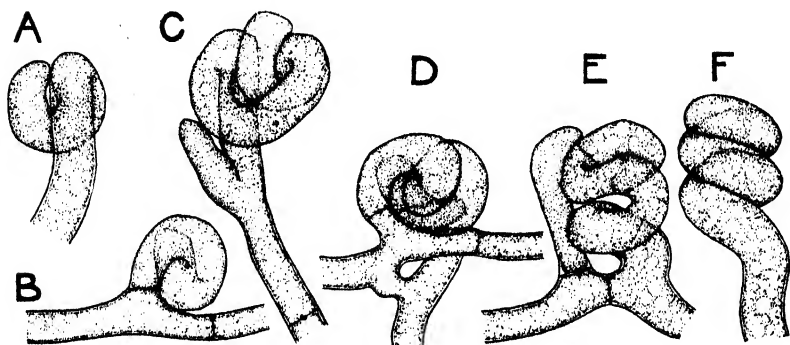


FIG. 2. Perithecial primordia of *Ceratostomella multiannulata* drawn from live material.  $\times 1700$ .

Many of the pioneer observers, having no precedents to guide them, were led to believe that in certain pyrenomycetous species one or more of the ascogonial cells divided repeatedly in three planes in such a manner that a parenchymatous core of cells eventually occupied the interior of the perithecium, and that asci developed from individual cells within the parenchymatous mass. This view was incorporated by De Bary (10) in his text on comparative morphology of fungi and is likewise considered with reservations by Gäumann (13). Some of the recent texts on structure and development of the fungi, however, ignore opinions of this sort, and in general the work of recent authors lends little credence to the view that multiplication of asci in Pyrenomycetes can result otherwise than as outgrowths from an oögonial cell or group of cells.

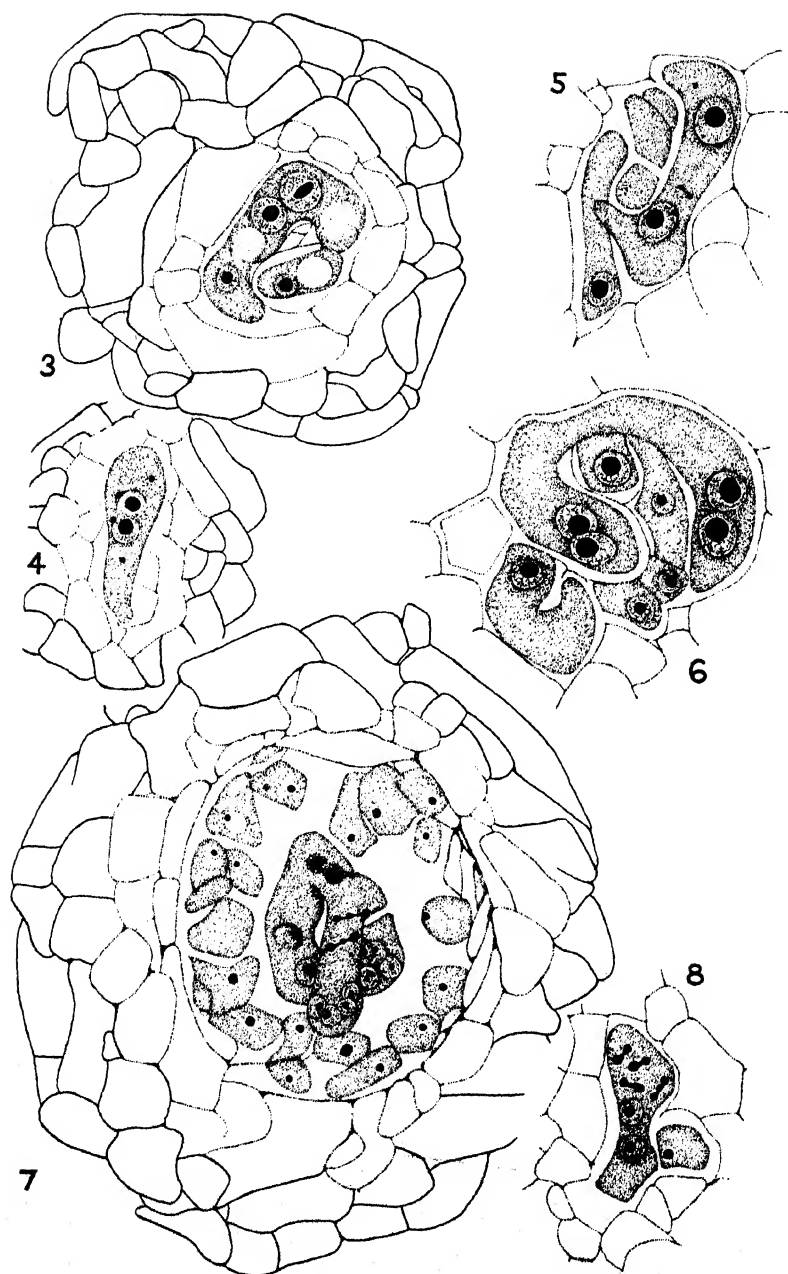
Apparently the first to express the belief that a parenchymatous mass of cells resulted from divisions of an oögonium was Kihl-

mann (16) who described a central parenchymatic cell mass derived from the division of a single fertile cell of the ascogonium in *Melanospora parasitica* Tul. Mattiolo (18) believed that a plectenchymatic group of cells was formed in the young perithecia of *Melanospora stysanophora* Matt. and *M. Gibelliana* Matt. Berlese (4), in describing the beginning of perithecium formation in *Melanospora globosa* Berl., concludes that the last cell of the spiral ascogonium divides in three dimensions and that asci appear later from the multiplication of cells thus formed. Nichols (22) suggested the possible origin of asci in *Ceratostoma brevirostre* Fuckel (later *Melanospora Zabelli* (Corda) Fuckel) from a central mass of parenchymatous tissue. Bainier (3) believed that progressive divisions of the ascogonium in *Melanospora* (*Papulospora*) *aspergilliformis* Eid. resulted in a group of cells from which asci later developed. Each of the above authors either neglected to illustrate the actual formation of a parenchymatous mass of cells from the ascogonium or the illustrations employed were inadequate; nevertheless their opinions were accepted until studies on other genera brought attention to the *Pyronema* type of development.

A fully illustrated paper dealing with the development of perithecia of the *Melanospora* type did not appear until 1917 when Vincens (25) published an account of the development of *Melanospora Mangini* and other members of the Hypocreales. According to Vincens the fertile and sterile regions of the ascogonium in *Melanospora* proliferate independently. The fertile portion divides to form a true parenchyma, while the sterile elements ramify in the space between the central parenchymatous mass and the wall of the perithecium. The sterile tissue disintegrates and asci develop within the central core of cells.

In 1928 Cookson (8) published a well illustrated account of development in *Melanospora Zamiae* Corda. Without knowledge of Vincens' work, she believed the central core of cells to be hyphal in origin, rather than parenchymatic. The core was thought to become differentiated into fertile and sterile elements, yet she was uncertain whether the two elements had a common or an independent origin. Although unable to trace the origin of the binucleate ascogenous cells, Cookson presumed that they





FIGS. 3-8.

developed from hyphal outgrowths of an enlarged cell of the archicarp. Until some investigator is able to follow the early stages in proliferation of the ascogonium in *Melanospora* the paper by Cookson may be regarded as the most plausible account yet given of development within the genus.

Recent work on the development of *Ceratostomella* by Mittmann (20) and by Andrus and Harter (1) (2) renders the facts in the case of *Melanospora* susceptible to a new interpretation. *C. multiannulata* especially, to be described below, seems to conform very closely with the published accounts of development in *Melanospora*. Yet it has been necessary to conclude on the one hand that no true parenchyma is formed by divisions of the ascogonial cells, and, on the other, that asci do not arise as true hyphal outgrowths from a fertile cell of the ascogonium. These conclusions are made possible by a detailed study of cell relations and the divisions of individual cellular units during the proliferative period leading up to ascus formation.

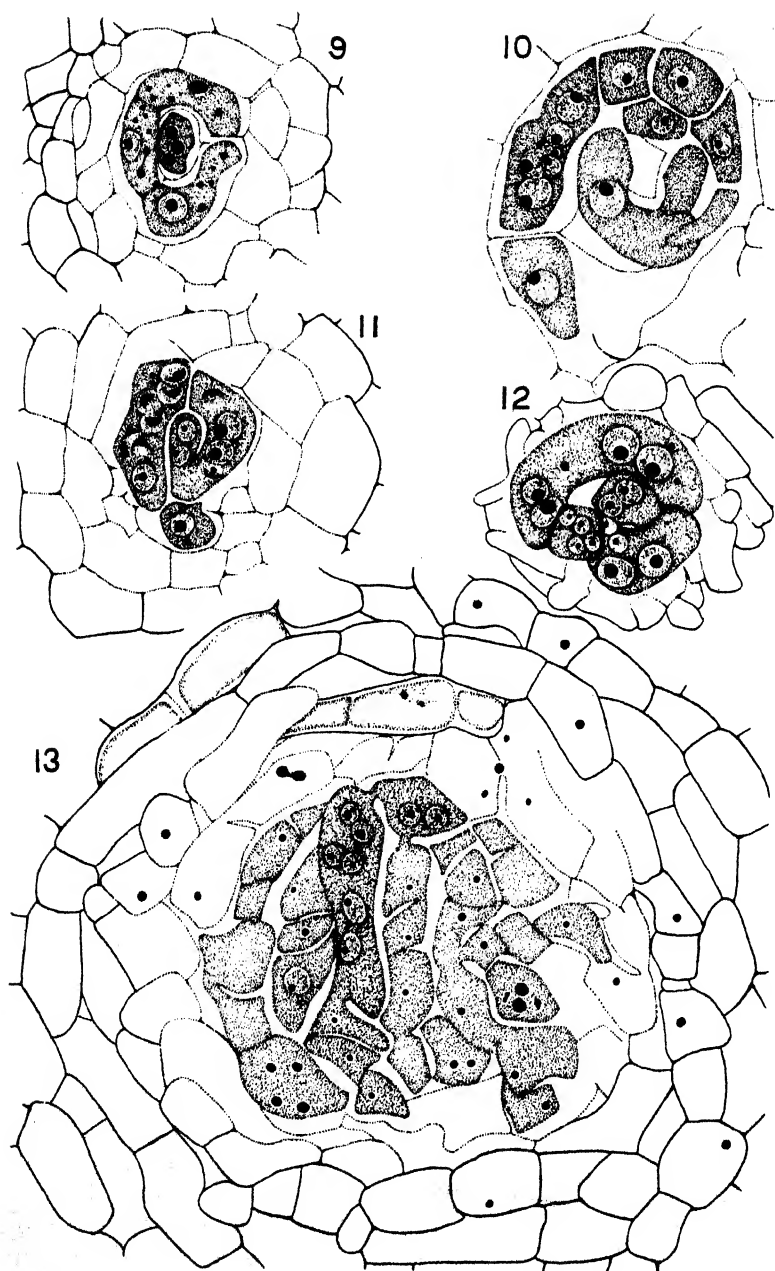
The writer is indebted to Dr. W. W. Diehl, Division of Mycology and Disease Survey, the U. S. Department of Agriculture, and Dr. R. F. Griggs, Professor of Botany, George Washington University, for valuable criticism during the course of the investigation, and to Dr. L. L. Harter, Division of Fruit and Vegetable Crops and Diseases, U. S. Department of Agriculture, who has encouraged a continuation of work in this field and who has assisted in the preparation of the manuscript.

#### METHODS

*Ceratostomella multiannulata* was isolated from lumber by R. W. Davidson, of the Division of Forest Pathology, U. S. Department of Agriculture, who supplied the writer with fixed material and with live cultures from which additional preparations were made. Fixations were made on the 6th day of growth on Thaxter agar. The habit of growth is such that perithecia in many stages of

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FIGS. 3-8. 3, a young perithecium showing the first division of the ascogonium into a central binucleate cell and terminal uninucleate cells; 4, the primary binucleate cell in a young perithecium; 5, an early stage in linear growth of the binucleate ascogonium; 6, linear growth of the fertile portion of the ascogonium; 7, the coiled fertile portion of the ascogonium previous to fragmentation, surrounded by uninucleate space-making cells; 8, multiplication of nuclei in the fertile portion of the ascogonium.  $\times 2700$ .



FIGS. 9-13.

development can be obtained in the same section. The earliest stages in development were also studied in live mounts.

Material for sectioning was fixed in either Bouin's solution or Flemming's strong solution diluted with an equal part of water. The agar blocks were imbedded in commercial parawax and sectioned 4 to 6  $\mu$  in thickness. Either fixative followed by haematoxylin gave superior results in demonstrating the early proliferation of the ascogonium. The triple combination (safranin, gentian-violet and orange G) was also tried but seemed generally inadequate. No combination has given entirely satisfactory delineation of nuclear structure in the ascus.

#### ORIGIN OF THE ASCOGONIUM

According to the evidence from the behavior of single spore strains a bisexual condition exists in *Ceratostomella multiannulata*. Davidson (unpublished) has observed that fertile perithecia are not produced in cultures derived from single ascospores or from single conidia, but that perithecia form abundantly where certain pairs of single spore isolates are grown in combination. The two kinds of sexually differentiated thalli appear to be approximately equal in number. There are slight differences in the appearance of cultures of the two sexes but apparently no very definite morphological characters by which they can be identified. Ascogonial coils, or rudimentary perithecia, are produced by cultures of both sexes, and where the two grow in contact on agar media two rows of perithecia are sometimes formed separated by a space of 2 to 3 millimeters. It is probable, therefore, that a reciprocal migration of nuclei occurs at the time of fertilization. The actual mechanism of fertilization will not be developed here but has been made the subject of a separate investigation.

The primary coil of the perithecium (FIG. 2), of which the terminal portion later becomes the ascogonium, may attain the proportions of the helicon frequently described for members of

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FIGS. 9-13. 9, linear growth of uninucleate elements of the ascogonium with a fertile (trinucleate) cell in the center; 10, origin of the uninucleate space-making cells; 11, fragmentation of the fertile portion of the ascogonium; 12, a stage in fragmentation of the coiled fertile portion of the ascogonium; an adjacent section shows uninucleate space-making cells; 13, a stage in fragmentation of the ascogonium.  $\times 2700$ .

the Aspergillaceae (13). An antheridium, generally similar to that described in *Ceratostomella fimbriata* (1) and *C. moniliformis* (2), appears to be present in at least some instances (FIG. 2C, E) but the question of how fertilization occurs will be disregarded at this time. The binucleate condition in the ascogonium has usually appeared by the time the first layers of enveloping hyphae are in place. The first division of the ascogonium is brought about by a simultaneous cleavage at two points, giving origin to terminal and basal uninucleate cells and a subterminal binucleate cell (FIG. 3). Figure 4, owing to the size of the perithecium is regarded as a stage previous to the first division.

The binucleate and uninucleate elements resulting from the first division of the ascogonium continue to develop independently. The original hyphal wall, still partially visible at the early stage shown in figure 3, later becomes completely dissolved and the cells occupying the perithecial cavity are essentially naked protoplasts. Proliferation of the binucleate or fertile cell at first consists of an extended linear growth (FIG. 5, 6, 75B), which, due to the limitations of the small perithecial cavity, is in the form of an irregular coil (FIG. 7, 11, 12, 75A). Linear cell growth is accompanied by rapidly recurring conjugate nuclear divisions (FIG. 7, 8). Although a well developed ascogonial coil is a multinucleate structure the nuclei are conspicuously arranged in groups of 2 or 4.

Ordinarily fragmentation of the fertile body does not begin to occur until the 8-nucleate stage is attained. In the meantime the uninucleate or sterile elements of the original ascogonium have undergone an independent proliferation in the region between the fertile coil and the margin of the perithecial cavity (FIG. 9, 10). Early growth of the uninucleate cells is likewise linear but the hyphal units later break up into numerous uninucleate cells that arrange themselves on the periphery of the cavity and surround the fertile coil (FIG. 7).

At approximately the stage shown in figure 7, the multinucleate fertile coil begins to fragment into independent units each possessing two or more nuclei. The appearance of the bodies undergoing division may suggest superficially the occurrence of division in 3 planes (FIG. 13), or the cleavage of a multinucleate

body into a parenchymatous mass of cells, such as was believed by some of the earlier observers to occur in species of *Melanospora*. This is evidently not the case since the dividing cells do retain a fundamentally linear relation to each other even though protoplasmic connections may be severed.

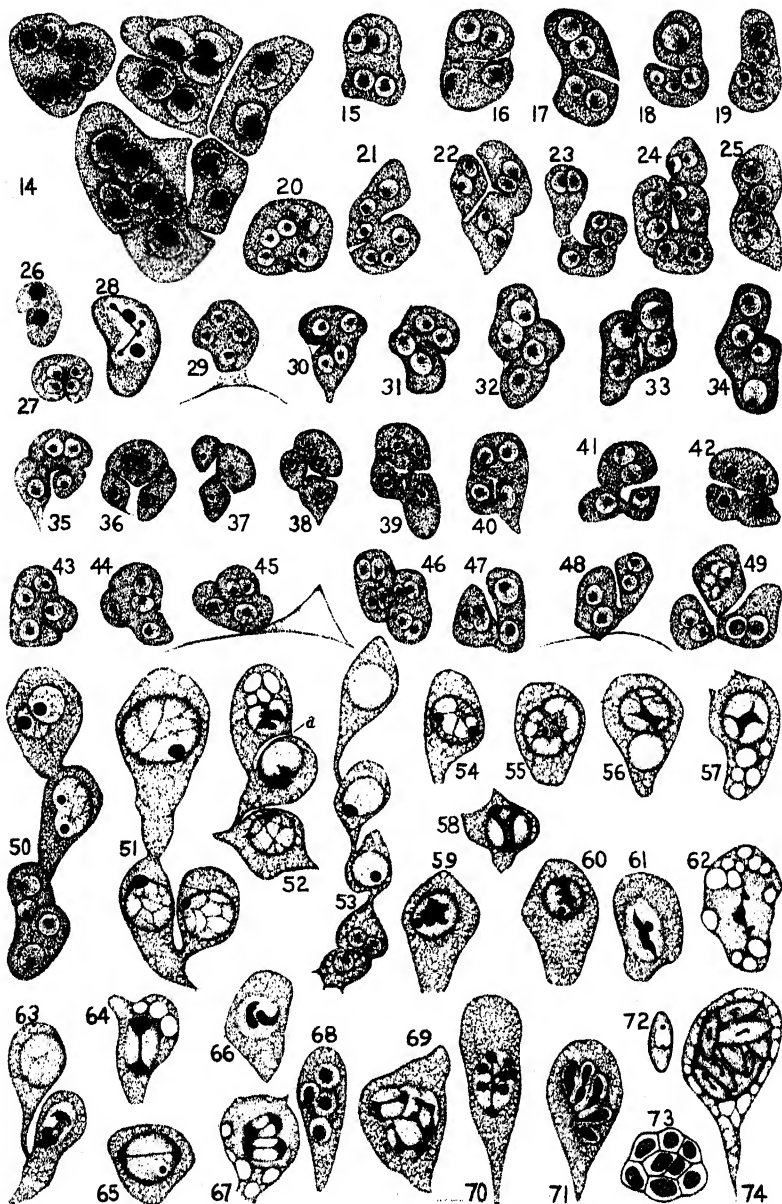
#### MULTIPLICATION OF ASCOGENOUS CELLS

An early and a late phase in the proliferation of ascogenous cells are conspicuous in *Ceratostomella multiannulata*. The transition from the early to the late phase of development is marked by a characteristic change in the organization of the perithecium. The early phase of cell proliferation begins with the fragmentation of the fertile multinucleate coil described above. Each fragment of the divided ascogonium continues to grow and divide independently. Eventually a multitude of the individual 2- or 4-nucleate cells occupy the perithecial cavity.

During the early divisions of the fertile cells there occur changes in the arrangement of the sterile or uninucleate elements. The uninucleate cells, which formerly surrounded the fertile coil on all sides (FIG. 7), withdraw from or become disorganized on the side of the cavity where the future beak or neck of the perithecium is to be formed.

At the beginning of beak formation, the perithecium is constructed as indicated in figures 1 and 75C. The fruiting body at that stage is composed of an outer pseudoparenchymatous region of thick-walled pigmented cells with an apical beak, and an inner region constructed of four layers: 1, a basal parenchyma of thin-walled, swollen and sterile cells; 2, a compact, crudely palisade layer of uninucleate cells, still undergoing some proliferation; 3, the fertile layer of loosely arranged independent ascogenous cells, containing two or more nuclei each; 4, a mostly vacant space, containing disorganized cells at the point where the ostiole will appear. The beak later becomes enormously elongated, and the interior of the fruiting body becomes altered in appearance.

At the beginning of the later phase in the proliferation of ascogenous cells, the uninucleate elements have ceased their development and become disorganized, so that the fertile cells,



FIGS. 14-74. 14, a group of ascogenous cells from a young peritheciium, showing the larger size of individual protoplasts and nuclei during the early phase of cell multiplication; 15-21, stages in simple unilateral cleavage during a later period of cell multiplication in the peritheciium; 22-25, cell linkage; 26, an

or the future asci, come to rest directly upon the parenchyma of thin-walled cells at the base of the perithecial cavity. This later stage is represented in figure 75D. Although the disappearance of the uninucleate elements at this time may suggest that they have functioned as space-making cells it does not appear that the latter function is a necessary one, since in *Ceratostomella fimbriata* (1) the space-making seems to proceed without any proliferation of uninucleate elements. Yet it is perhaps true that the uninucleate independent cells that undergo a limited development in perithecia of *C. multiannulata* correspond in certain respects to the paraphyses in discomycetous species.

A more important feature of the later phase in the proliferation of ascogenous cells is the appearance of the crosier type of cell division. There are few figures showing nuclear division at this stage in *Ceratostomella multiannulata* yet the conformation and linkage of dividing cells, together with the position of nuclei, demonstrate that crosier divisions as well as simple cleavages occur in this species (FIG. 15-49) as well as in *C. moniliformis* and *C. fimbriata* (2).

Changes in cell shape play an important role during cell early stage in crosier formation; 27, a stage in cleavage that may result in a direct or an indirect cell division; 28, a stage in nuclear division in a crosier; 29, an ascogenous cell in close contact with a sterile parenchymatic cell at the base of the perithecial cavity; 30-34, all appear to be stages in direct or unilateral cell cleavage and emphasize changes in cell shape (a persistent surface membrane is frequently observed at points of cleavage); 35-37, the 3-cell stage in crosier formation; 38-42, stages in fusion of uninucleate portions of the crosier; 43-45, an indirect cell division that appears to be intermediate between crosier formation and a process of budding (contact with disorganized walls of the sterile parenchyma is indicated in figure 45); 46, change in cell shape accompanying incomplete cleavage of a 4-nucleate ascogenous cell; 45-53, linkage of ascogenous cells and young asci (cleavage does not appear to have been completed at *a*, of fig. 52); 54, 55, nuclear fusion at the beginning of ascus formation; 56-59, first nuclear division in the ascus, showing the gathering or condensation of chromatic material; 60-62, first nuclear division, showing the characteristic 4-lobed chromatin mass at metaphase and early anaphase; 63-65, anaphase of the first nuclear division; 66-68, stages in the second nuclear division in the ascus; 69, a stage in the third nuclear division in the ascus; 70, a young ascus with the 8 nuclei arranged in a crude circle and joined together by strands of protoplasm; 71, a young ascus with spore rudiments radiating from a common lateral base; 72, a nearly mature ascospore, showing two chromatic centers in a single nucleus; 73, a cross section of a mature ascus; 74, a nearly mature ascus.  $\times 2700$ .



division. Having observed the various intermediate steps (FIG. 30-33) one can easily visualize the gliding motions that must occur while such a structure as that represented in figure 29 assumes the appearance shown in figures 34 and 50. By means of change of shape alone, a 4-nucleate "crosier" of the type shown in figure 43 may contrive to have joined two distal uni-nucleate points without need of fusion; which is equivalent to saying that two terminal points of such a crosier may fuse completely without their ever having been entirely separated.

In the processes of division and changes in cell shape and cell linkage evidence can be found for the presence of a protoplasmic surface membrane (FIG. 30-32, 36) enclosing the otherwise apparently naked cells. The slender protoplasmic strands which sometimes provide a continuity between asci (FIG. 38, 39, 52) may be constructed wholly of the more tangible surface film present on the naked protoplasts, but it seems more probable that connecting filaments of the type shown are strands of cytoplasm corresponding to the plasmodesma that may be observed in a series of walled cells.

The crude chains of cells illustrated in figures 49-53, and similar linked groups described in *Ceratostomella moniliformis* and *C. fimbriata* (1) (2), comprise the only suggestion of ascogenous hyphae observed in the genus. It is important to emphasize that they represent independent groups of cells and not merely parts of a continuous hyphal network such as is to be observed in discomycetous species. Linkages of the kind illustrated are not found among the freely dividing cells that result from the first fragmentation of the ascogonium (FIG. 14) and the fact suggests the interpretation that each one of the multitude of independent cells resulting from the early proliferative stage is equivalent to a separate ascogonium and that each such ascogonium gives rise to an independent group of asci. Such an interpretation seems to offer no advantage over the view that independent cell proliferation in perithecia of *Ceratostomella* corresponds to the proliferation of ascogenous hyphae in discomycetous species.

## NUCLEAR BEHAVIOR IN THE ASCUS

Individual asci of *Ceratostomella multiannulata* are smaller than in any related species investigated and also they have been difficult to stain. Stages in nuclear fusion in the ascus are observed frequently (FIG. 54, 55) but they reveal no new details concerning the process. The fusion nucleus is perhaps exceptionally large in proportion to cell size; while the nucleolus is proportionately small. The stainable contents of the nucleus consist of a few faint strands that often extend the entire breadth of the nuclear vesicle (FIG. 51, 52). An appearance such as illustrated in figure 58 seems to precede the first nuclear division.

First division stages are shown in figures 56 to 65. The nucleolus often persists during the first division but not thereafter. There appear to be no more than four discrete bodies of chromatin distributed along the crude spindle (FIG. 59-62); a single 2 to 4-lobed mass is commonly observed. Two chromatin bodies, or a single compound body, appear to move to each pole (FIG. 63). Near the close of the first division single masses of chromatin are observed on opposite faces of the original nuclear vesicle and are connected by a single slender filament (FIG. 64, 65).

The beginning of the second nuclear division seems to be indicated by such an appearance as that shown in figure 66. Later the two spindles appear to occupy separate hyalospheres (FIG. 67) and the original nuclear vesicle is no longer visible. The few intermediate stages seem to indicate that no reduction in the amount of chromatin or in number of chromatin bodies occurs during the second nuclear division.

During the third nuclear division the four advanced spindles (FIG. 69) appear to occupy separate hyalospheres. There is a reduction in the amount of chromatin but it would be presumptive to state that there is a reduction in number of chromosomes. An inner vesicle such as usually appeared at approximately the 4-nucleate stage in *Ceratostomella moniliformis* and *C. fimbriata* (2) has not been observed in *C. multiannulata*.

## MATURATION OF ASCI

A cleavage of the cytoplasm surrounding the inner spore-producing region in *Ceratostomella moniliformis* (2), and the

presence of an endogenous wall in *C. fimbriata* (1) (2), in a position corresponding to the cleavage in *C. moniliformis*, were conspicuous features of advanced stages in ascus formation in those two species and were regarded as evidence of the vesicular nature of the spore-producing central region of the ascus. The non-appearance of such a vesicle in *C. multiannulata* is perhaps the one point in which ascus formation differs fundamentally from the two species mentioned above.

Although there appears to be no true ascus wall, the peripheral layer, like the intervacuolar layers, is more substantial and remains entire up to the time of spore wall formation (FIG. 74). The process of spore delimitation has not been followed in detail yet it evidently follows a course similar to that observed in *C. moniliformis* and *C. fimbriata* (2), except that the spore-producing region does not appear to be vesiculate at any stage. The eight nuclei become arranged in a crude circle, with filaments of an unidentified nature connecting them all to a common point or base (FIG. 70). Later the young spores appear to be attached to a common base (FIG. 71) which is usually lateral to the long axis. Figure 73 is a cross-section and figure 74 a longitudinal section of nearly mature asci. The spore walls seem to originate from the cytoplasmic layer at the margin of each spore vesicle. A membranous attachment, such as was observed in *C. moniliformis* and *C. fimbriata* (2) has not been observed on ascospores (FIG. 72) of *C. multiannulata*.

#### DISCUSSION

It is probable that the most important fact brought out in the recent investigations on *Ceratostomella* concerns a fundamental character possessed in common by several species, namely, the independent proliferation of ascogenous cells following fragmentation of the ascogonium. It is believed that the type of cell proliferation preceding ascus formation demonstrated to occur, first by Mittmann (20) and later by Andrus and Harter (1) (2), and in the present account, represents a fundamentally different course of development from that which occurs in species of Discomycetes as represented by the lichen fungi and *Pyronema* (15). In discomycetous species a multiplication of asci follows

direct hyphal outgrowths from an ascogonium. In the group of Pyrenomycetes represented by *Ceratostomella* the ascogonium divides into numerous independent binucleate cells each of which continues to divide independently.

Intermediate between the type of cell proliferation that proceeds from the ascogonium in Discomycetes and the type that occurs in *Ceratostomella* may be found that occurring in such species as *Xylaria tentacularia* (6) and *Hypoxylon coccineum* (17) in which the ascogonium becomes separated into several independent portions, each of which presumably gives origin to a system of ascogenous hyphae. Other types of development are represented by those groups, such as the mildews and the Laboulbeniales, in which a single ascus or a comparatively few asci are produced in a perithecium. In certain species the oögonium or single-celled ascogonium would appear to be transformed directly into a single ascus. In others the ascogonium apparently divides into two or more portions which develop directly into asci. In still other species the asci originate as single-celled outgrowths from the ascogonium, in which case they have been called ascogenous hyphae (12) (21). Considering all of the above types of development there is reason to look upon the originally single-celled ascogonium or oögonium as a potential ascus, which may develop into a single ascus or may undergo various types of proliferation that lead to a multiplication of asci. The differences between the various types of proliferation, however, may be important ones and conceivably may have great taxonomic value.

It is notably the case that, previous to the work of Mittmann (20) and of Andrus and Harter (1) on *Ceratostomella fimbriata*, all attempts to describe a system of independent cell divisions preceding ascus formation were met with skepticism. The views expressed by the above writers also have been rejected by Gwynne-Vaughan and Williamson (14), and may continue to be regarded doubtfully by those who presumably have not had occasion to examine the species. Previously Andrus and Harter (1) introduced a discussion of publications concerning the genus *Monascus*. Early in the present account numerous references are made to investigations in the genus *Melanospora*. In respect to both genera there has been controversy over the question of



FIG. 75. *Ceratostomella multiannulata*. A, photomicrograph of a young perithecium, showing an early appearance of the coiled and deeply stained ascogonium,  $\times 600$ ; B, photomicrograph of a young perithecium, showing the first divisions of the ascogonium into uninucleate and binucleate cells,  $\times 600$ ; C, photomicrograph of a stage at the beginning of beak formation, showing the binucleate fertile cells surrounded by uninucleate "space-making" cells,  $\times 600$ ; D, a mature perithecium with crude chains of asci in direct contact with the sterile pseudoparenchyma at the base of the cavity,  $\times 500$ .

whether the first proliferation of the ascogonium led to the formation of a true parenchyma in the perithecial cavity or whether the proliferation was in the form of hyphal growths.

In the present investigation it has been possible to supply some of those missing details that led previously to uncertainty regarding the early proliferative stages in the perithecia of *Melanospora*. *Ceratostomella multiannulata* has proved to be favorable material for a detailed study of the early fragmentation of the ascogonium and the later divisions of the independent ascogenous cells. It is believed that the processes of cell multiplication, fully described and illustrated above, require no further discussion. It should be repeated, however, that the facts do not support the often expressed belief that asci may arise from a parenchymatous mass of cells within the perithecium. On the other hand they demonstrate that the first proliferation of the ascogonium need not be in the form of hyphal outgrowths.

#### SUMMARY

The development of the ascogenous system in the perithecium of *Ceratostomella multiannulata* follows the fragmentation of an originally binucleate unwallled ascogonium. The first division of the ascogonium is indirect and results in the formation of two uninucleate fragments and a single binucleate cell. The binucleate or fertile portion of the ascogonium undergoes a linear growth accompanied by conjugate nuclear divisions. At approximately the 8-nucleate stage, the fertile coil divides into independent units of 2 or 4 nuclei each. Each unit continues to divide independently. The uninucleate fragments resulting from the first division of the ascogonium undergo an independent proliferation within the perithecial cavity and give origin to a layer of space-making cells that at one stage surrounds the group of binucleate protoplasts. The uninucleate or space-making cells later collect at the base of the perithecial cavity where they dwindle in number and disappear before the perithecium reaches maturity.

Successive divisions of the binucleate fragments of the ascogonium result in the formation of a multitude of minute, independent and unwallled cells that later develop into asci. Stages

in division of the ascogenous cells include the crosier as well as several other, both direct and indirect, types of cell cleavage. Cell divisions are accompanied by significant changes in cell shape. Short chains or independent groups of cells constitute the only suggestions of hyphal growths to be observed in the perithecium. Developing asci are frequently linked together in short series, while actively dividing cells are mostly unattached.

Actively dividing cells in an advanced perithecium cover the lower face of the perithecial cavity and appear to consume the pseudoparenchyma of thin-walled cells lining the interior. The "space-making" function, therefore, does not appear to be restricted to the system of uninucleate cells that is present in the perithecium at an early stage of development.

The asci are unwallled. Ascospore formation is restricted to a central region of the ascus cytoplasm which, however, is not clearly vesiculate. Immature ascospores appear to be attached at a common base which is usually lateral to the longer dimension of the ascus. Deliquescence of the ascus involves a dissolution of the peripheral layer of cytoplasm and a separation of the closely compact group of 8 spores.

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## NORTH AMERICAN POLYPORES—I. POLYPORUS SQUAMOSUS AND ITS VARIETIES

PAUL W. GRAFF

There seems to be considerable uncertainty with regard to the distribution and prevalence of *Polyporus squamosus* (Huds.) Fries, within its North American habitat. Nor has there been any clear recognition of its varieties, either here or abroad. It has been said that this species is of common occurrence in the United States, but it has been more generally reported as rare. American distribution has been limited by some to the Northeastern States, though it has been collected in Ontario, Manitoba, Kansas and Colorado, and the present report extends its range to western Montana. The fungus is said to be found attacking only deciduous trees, and to produce mature pilei that are typically from 5 to 40 cm., wide. But in Minnesota, it has been intimated, *P. squamosus* grows on the ground where it is said to attain a width of 7 feet [210 cm.] and a weight of 40 pounds. All of which shows just how uncertain our information is with regard to the habits of this polypore.

*Polyporus squamosus* has always been considered, by both European and American mycologists, to be a species based upon *Boletus squamosus* as described by Hudson. They have failed to recognize the fact that it was Micheli (1729) and not Hudson (1778) who first described this fungus under its generally accepted specific name. It is true that Hudson did give a brief description of this species in his "Flora Anglica." I can find no intimation, however, that he considered it a new species. Micheli described this fungus as *Agaricum squamosum*, and forty-nine years later Hudson transferred it to the genus *Boletus* in order to bring it into conformity with his more advanced scheme of classification. In doing this Hudson made no claim to the discovery of a new species. This fact is irrefutable for he includes a brief synonymy. He fails to tell us, however, why he gave preference to Micheli's name instead of using that proposed by Sterbeck (1675), though

*Auricula flammea* of this earlier writer is among his synonyms. It is evident that, from an historical viewpoint, Hudson's description has no more significance than one appearing in any local descriptive flora. And yet, because of nomenclatorial idiosyncrasies, followers of the International Code must give Hudson all the credit, and relegate any citation of Micheli's original name to a place among synonyms.

The "North American Flora" (Murrill 1908) includes this species under the name *Polyporus caudicinus*. Murrill (1903) recognized the fact that *Boletus caudicinus* of Scopoli (1772) antedated *Boletus squamosus* as published by Hudson, but failed to trace the original source of Hudson's name. On this basis he changed the name of the fungus to *Polyporus caudicinus* (Scop.) Murr. While doing this Murrill also failed to recognize the fact that this same fungus had been described by Sterbeck (1675) as *Auricula flammea*, by Dillenius (1718) as *Agaricus villosus*, by Schaeffer (1763) as *Boletus Juglandis* and by Haller (1768) as *Polyporus sessilis* before Scopoli's publication appeared. He should have used the name *Polyporus flammeus* had he wished to set aside the International Code and abide by strict priority. The following year Murrill (1904) does include *Boletus Juglandis* Schaeff., as a synonym, but gives Schaeffer's date of publication as 1774 instead of 1763, thus through an error saving his combination.

In spite of its prevalence, occasional errors of identity and misinterpretations have crept into the literature. We find that at times *Polyporus giganteus* (Pers.) Fries, has been considered synonymous with *P. squamosus*. The cause of this error can possibly be traced to Harzer (1845), who described and very clearly figured the latter species under the former name. *P. giganteus* and *Boletus acanthoides* of Bulliard (1790) are equivalent, and very different from *P. squamosus*.

*Boletus elegans* of Bolton (1789, PL. 76) has appeared at times as a synonym of both *Polyporus giganteus* and *P. squamosus*. Obviously this species of Bolton's cannot be a synonym of both of these polypores. It clearly belongs among the numerous synonyms of *P. giganteus*. In this connection one must not confuse *B. elegans* Bolt., with *B. elegans* Bull., two very different fungi.

*Polyporus squamosus* is clearly distinct and recognizable from other members of the genus *Polyporus* with large favoloid pores. The species has a long history, and the distinction of being one of the first members of the polyporoid group to have been illustrated in a clearly recognizable manner. Clusius (1601) has given us, in his work on Hungarian fungi, a woodcut so well executed as to make perfectly clear the fungus he intended to portray. Sterbeck (1675) was the next to clearly illustrate this plant. In his "Theatrum Fungorum" there are two copper-plate engravings, both of which represent *P. squamosus* in an unmistakable manner. With the numerous illustrations and descriptions that have subsequently appeared there would seem to be little reason why the species should not be readily recognized, and yet its boundaries and limitations have been variously defined.

In Europe, *Polyporus squamosus* is one of the most common causes of timber decay among a wide variety of living deciduous trees. It is said to attack those of the forest, park or garden indiscriminately. The only exception to its partiality for deciduous trees has been noted in England where the fungus has been reported parasitic on yew.

The situation in North America is apparently quite different from that in Europe. Though found occasionally in the region from West Virginia, Missouri, Kansas and Colorado northward, and east of the Rocky Mountains, collections are rare and published reports are based upon few specimens.

Murrill (1904, 1908) reports the species as collected in Ontario by Dearness, in Connecticut by Underwood and New York by himself. White (1905) reports two collections from Connecticut, one from the vicinity of East Hartford and the other from Tolland County. In none of these cases is the host mentioned, and both specimens are missing from the White collection at the Connecticut State College.

Peck (1875) cites a collection found growing upon the trunk of an elm at Albany, New York. More recently Lowe (1934) reports its presence in New York state upon the American elm and black willow. McIlvaine (1900) adds Massachusetts with material collected by Sprague, Iowa by Macbride, and West

Virginia, New Jersey and Pennsylvania by himself, but without further mention of host than "fallen trunks and on stumps." His opinion is that the species is rare in America. McIlvaine's plate (PL. 130) would seem to approach the form described as *Polyporus fagicola* Murr., though somewhat larger and possessing a dark based stipe. Overholts (1933) also reports the species from Pennsylvania, and as growing from wounds in living deciduous trees and rare.

Apparently Pennsylvania and West Virginia are as far south as *Polyporus squamosus* has been reported along the Atlantic seaboard. Passing to the westward one finds it mentioned first by Cragin (1884) from near Topeka, Kansas, and later by Overholts (1914, 1915), who says it is rare in the states of Ohio, Minnesota, Missouri and Kansas. Overholts, unfortunately, only limits his hosts as living deciduous trees. At the same time Neuman (1914) reports a collection made in Madison, Wisconsin, but gives no host and declares the fungus to be rare. Dodge (1914) reports gathering one centrally stiped plant at Algona, Wisconsin, on maple. Kauffman (1917) desiring, as he says, to put on record data of many years concerning the distribution of Basidiomycetes in Michigan, published an index in which he reports *P. squamosus* on elm and willow.

The most westerly collection reported is that of Shope (1931), who found the species growing upon *Populus* spp., in the plains zone of Colorado. To the northward Bisby, Buller and Dearnness (1929) report "*Polyporus squamosus* Pers.," as rare and seen but twice in the vicinity of Winnipeg, Manitoba. Presumably this reference is to our species, though the authorship of the fungus is delegated to Persoon who, while he gave this particular fungus three new names, did not make use of this one.

There are, in the herbarium of The New York Botanical Garden, two apparently unreported collections that are of importance in extending the range of our fungus. A collection made by Lansing, in Jackson Park, Chicago, from the base of a cottonwood tree adds the state of Illinois to our list. No other data accompany this collection. The second is an excellent specimen gathered by Dr. H. D. House, May 26, 1911, from a dead log of *Aesculus octandra* Marsh, at Sunburst, Haywood

County, North Carolina, at an altitude of 3,200 feet. This is of importance as showing that the distribution may extend southward in the Appalachian Mountains, and in adding a new host. A third collection, one made by Ellsworth Bethel in Colorado, is also worthy of note, though without further data, as seconding Shope's report from that western state.

Personally I have collected *Polyporus squamosus* but three times. The first collection was made on the western slope of the Mission Mountains, in the vicinity of Yellow Bay, Flathead Lake, Montana, at approximately 3,500 feet elevation, July 23, 1918, on living *Populus trichocarpa* T. & G. The second was found in the vicinity of Bigfork, at the northern end of Flathead Lake and 3,000 feet elevation, July 7, 1921, growing from the base of an over mature *Acer glabrum* Torr. Both of these collections were deposited in the herbarium of the University of Montana Biological Station, Yellow Bay, Montana. While these hosts are of some interest, the chief interest in these collections lies in the fact that they were made in a locality west of the Continental Divide. Because of this they must be considered, at least for the present, as sporadic occurrences, though it may be admitted that the Northwest has been explored but comparatively little by mycologists.

My third collection was made at Storrs, Tolland County, Connecticut, June 18, 1934, growing on living *Ulmus americana* L., in mixed deciduous woods. The tree had apparently suffered mechanical injury near the base, and the sporophores were growing from this region. This collection has been divided between the herbaria of the Connecticut State College and The New York Botanical Garden.

Negatively it should be noted that Maneval (1926) does not include *Polyporus squamosus* in his extensive list of parasitic and wood destroying fungi of Missouri. Also Anderson et al. (1926), while including *P. squamosus* as a parasite on *Acer Negundo* L., from Minnesota in their "Checklist of Diseases of Economic Plants in the United States," do not mention this species in connection with any other host nor from any other locality.

It is apparent that, while we have some knowledge regarding

the geographical distribution of this species in America, we have but little respecting its host range or host preferences. Actually *Polyporus squamosus* has now only been reported as parasitic on six host species within this region, and three of these are additions that have been made in this paper. It is unfortunate that, in the majority of the reports cited, the host has evidently been considered of negligible importance.

The synonymy of *Polyporus squamosus* and, as this would denote, its literature are not well known. For this reason I am including a reasonably complete synonymy. Aside from the species there are also three readily distinguishable varieties. One of these is solely European, one both European and American while the third seems to be confined to the United States.

1. POLYPORUS SQUAMOSUS (Huds.) Fries, Syst. Myc. 1: 343. 1821.

*Boletus squamosus* Huds. Fl. Angl. Ed. 2, 626. 1778.

*Auricula flammea* Malchi Sterb. Theat. Fung. 105, pl. 13. 1675.

*Agaricum squamosum*, Ilcibus Mich. Nov. Plant. Gen. 118. 1729.

*Boletus Juglandis* Schaeff. Ic. Fung. Bavar. 2: 101-102, pl. 101-102. 1763.

*Polyporus sessilis* Hall. Hist. Pl. Indig. Helv. 202. 1769.

*Boletus caudicinus* Scop. Flor. Carn. Ed. 2, 2: 469. 1772.

*Agaricus aureus* Batt. Fung. Hist. 68, pl. 37, fig. A-B. 1775.

*Boletus cellulosus* Lightf. Flor. Scot. 2: 1032. 1777.

*Polyporus Ulmi* Paulet, Traité Champ. 2: 102. 1793.

*Boletus platyporus* Pers. Syn. Fung. 521. 1801.

*Polyporus flabelliformis* Pers. Myc. Eur. 2: 53. 1825.

*Polyporus tigrinus* Pers. Myc. Eur. 2: 54. 1825.

*Polyporus squamosus* (Huds.) Fries var. *crassipes* Kickx, Rech. Flor. Crypt. Fland. 5: 46. 1855.

*Polyporus squamosus* (Huds.) Fries var. *laevipes* Kickx, Rech. Flor. Crypt. Fland. 5: 47. 1855.

*Polyporus squamosus* (Huds.) Fries var. *aureus* Kickx, Flor. Fland. 2: 223. 1867.

*Bresadolia paradoxa* Speg. Anal. Soc. Sci. Argent. 16: 15. 1883.

*Cerioporus squamosus* (Huds.) Quél. Ench. Fung. 167. 1886.

*Melanopus squamosus* (Huds.) Pat. Hymen. Eur. 137. 1887.

*Polyporus squamosus* (Huds.) Fries, f. *erecta* Bres. Fung. Trid. 2: 27, pl. 133. 1892.

*Polyporus caudicinus* (Scop.) Murr. Jour. Myc. 9: 89. 1903.

*Bresadolia caucasica* Schest. in Magnus, Hedwigia 50: 101, pl. 2. 1911.

Basidiocarps large, solitary or in imbricated, caespitose clusters; pileus dimidiate, reniform or becoming flabelliform, 5–40 cm. broad, 0.5–4 cm. thick; surface smooth, ochraceous-yellow to brown or fulvous, covered with large, appressed, dark brown scales which may be close together in young specimens but further apart in older plants; margin thin, involute, slightly wavy, entire; context thin, white when fresh, soft and fleshy when young, becoming tough-fleshy and drying spongy- to corky-fragile, homogeneous, 0.3–3.2 cm. thick, with hyaline, branching, thick-walled hyphae, 4–8  $\mu$  in diameter; tubes white to yellowish, darker on drying, at first shallow pits, developing into large, angular, favoloid pores, 8 mm. deep, 1–3 mm. tangential diameter, 1.5–6 mm. radial diameter, edges of dissepiments become thin, entire to dentate or lacerate at maturity, decurrent as shallow pits or reticulations; stipe lateral or excentric, rarely subcentral, 1–5 cm. long, 1–3 cm. thick, sometimes rudimentary, at first obese, white to yellowish or pale buff and reticulate-poroid above, black or dark brown and sometimes areolate below, solid, homogeneous, base somewhat bulbous; hymenium compact, 20–30  $\mu$  thick; basidia clavate, 8  $\mu$  broad; spores hyaline, smooth, elongate-ovoid to ellipsoid, apiculate, 12–16  $\times$  4.5–6 (14  $\times$  5)  $\mu$ ; cystidia wanting; vegetative hyphae 6–8  $\mu$  in diameter.

TYPE LOCALITY: Northern England.

HABITAT: *Acer glabrum* Torr.; *Acer Negundo* L.; *Aesculus octandra* Marsh; *Populus trichocarpa* T. & G.; *Salix nigra* Marsh; *Ulmus americana* L.; also *Acer*, *Populus* and *Salix* species undetermined. Late spring and summer.

DISTRIBUTION: Rare in Massachusetts, Connecticut, New

York, Pennsylvania, West Virginia, North Carolina, Ohio, Michigan, Illinois, Missouri, Arkansas, Wisconsin, Minnesota, Iowa, Kansas, Montana, Colorado, the provinces of Ontario and Manitoba; very common in Europe; Altai, Mongolia, Asia (Burt); Queensland, Australia (Cooke); Paraguay, South America (Spegazzini).

ILLUSTRATIONS: Lloyd, Photo. Am. Fungi, *pl.* 5. 1897; McIlvaine, One Thousand Am. Fungi, *pl.* 130. 1900; Hard, Mushrooms, *fig.* 325. 1908; Duggar, Fung. Dis. Plants, *fig.* 223-224. 1909; Neuman, Wisc. Geol. Nat. Hist. Surv. Bull. **33**: *pl.* 14, *fig.* 51*b*, *pl.* 15, *fig.* 51*a*. 1914; Hesler, Jour. Tenn. Acad. Sci. **4**: *fig.* 2. 1929; Shope, Ann. Missouri Bot. Gard. **18**: *pl.* 29, *fig.* 1-2. 1931.

*Polyporus squamosus* and its varieties cause a white heart-rot of timber. In Europe the loss due to this fungus is considerable because of the prevalence of the disease and its wide range of hosts. In the United States the loss is negligible because of the rarity of the fungus and greater host selectivity. With its spread, however, there is a potential danger. The fungus normally attacks living trees as a wound parasite, but habitually persists in a saprophytic state in fallen or felled timber and the remaining stumps.

While *Polyporus squamosus* has never been found a common species at any time, its presence in North America has been recognized since 1875, when it was first reported by Peck. In a number of the states enumerated but one collection has been reported and in several not more than two.

It will be noted that I have not given recognition to the upright growing form with a tendency toward an ochraceous-yellow color among the varieties of this species. Bresadola (1892) segregates this as forma *erecta* in his earlier work, but later (1931) concludes that this is unwarranted, though Kickx (1867) had previously given it varietal rank as var. *aureus*. This variation seems to be associated rather definitely with a saprophytic development. Collections to which the upright, infundibuliform growth and yellowish color have been ascribed appear to have been gathered from tree stumps or dead and more or less aged timber. It seems to me a purely ecological variation.



American specimens usually mature as single pileate plants, and are but rarely found developing in the caespitose manner that is apparently more usual in Europe. Nor do they reach the size reported from western Europe where the largest forms seem to have been collected. Specimens gathered in the United States rarely exceed 20–30 cm. in breadth. Clements (1910), in reporting *Polyporus squamosus* from Minnesota, says that it occurs occasionally on the ground in woods, and is said to attain a width of 7 feet and a weight of 40 pounds. Clements' record is of particular interest being the only time this fungus has been reported growing upon the ground. McIlvaine (1900), without any reference to locality, says that this species has been known to attain a circumference of 7 feet 5 inches, and a weight of 40 pounds.

In localities where this fungus is most prolific and variable many specimens of considerable size have been found. In eastern Europe a width of 50 cm. has been reported, and considered exceptionally large. To the westward, on the other hand, we find that large specimens are not infrequent, and that in England, Hooker (1821) reports a plant of this species which he says, "Has regularly made its appearance for several years past, on the stump of an ash, at Dalbeth, near Glasgow. In 1810 it attained an extraordinary size, being 7 feet 5 inches in circumference, and weighing, after having been cut four days, thirty-four pounds avoird."

In Fries' (1828) description of *Polyporus squamosus* the pores are described as at first minute, then large and angular. Lloyd (1911) offers objection to this, and gives as his opinion that they are "at first large, angular, shallow, merely large reticulations in fact, and really become smaller in diameter as they grow in depth."

From my own observations, based upon freshly gathered material, it appears that the pores are at first shallow and separated from one another by relatively broad dissepiments, thus causing them to appear small. Approaching maturity, these dissepiments grow in length and become very thin. As a result of this the pores present the appearance of increasing in diameter as well as depth. It is true that these irregular pores

may become apparently larger by the partial breaking down, or cessation in growth, of a wall before reaching its mature length. In this manner a merging of adjacent pores may take place. This, however, only occurs at rare and very scattered intervals. As for becoming smaller in diameter as they grow in depth, this could only apply to old specimens that are drying with an accompanying shrinkage and curling of the pileus. Lloyd says that his observations were based upon dried specimens.

The upper surface of *Polyporus squamosus* reminds one most strikingly of *Lentinus lepidus* Fries. Fries recognized this and says in his discussion, "*Ag. lepidei*, cui haec species analoga, similis." In pore character there is a distinct trend toward the genus *Favolus*.

2. *POLYPORUS SQUAMOSUS* (Huds.) Fries, var. **polymorphus** (Bull.) comb. nov.

*Agaricus ramosus cornu reniferi referens* Blacks. Specim. Bot. Plant. Angliae 2, pl. 1. 1746.

? *Clavaria Hypoxylon* var. *B.* Huds. Flor. Angl. Ed. 2, 2: 639. 1778.

*Boletus polymorphus* Bull. Herb. France pl. 144, fig. A. 1782.

*Boletus rangiferinus* Bolt. Hist. Fung. Halifax 3: 138, pl. 138. 1789.

Having much elongated and somewhat curved stipes, which may branch irregularly several times, while the pilei are proportionately reduced in size. The basidiocarp, as a whole, is very irregular and sometimes quite dendroid in form. The pilei, in extreme cases, may be of the same, or only slightly greater, diameter as the stipe, or may even be in part wanting. There is, however, much variability in this respect. The pores are often less favoloid than in the species, being more shallow and having thicker dissepiments. Otherwise the characters are the same as those of the species.

TYPE LOCALITY: France.

HABITAT: Dead and fallen timber, and stumps.

DISTRIBUTION: England, France.

ILLUSTRATIONS: Blackstone, Specim. Bot. Plant. Angliae, *pl.* 1. 1746; Bolton, Hist. Fung. Halifax 3: *pl.* 138. 1789; Bulliard, Herb. France *pl.* 144, *fig.* A. 1782; Sowerby, Engl. Fungi 3: *pl.* 266. 1803.

Blackstone (1746) has apparently given us one of the earliest descriptions of this variety. He has also given us, in his first plate, a very characteristic illustration of this interesting fungus. Of his specimen, he says, "This elegant Species was found in 1744, growing on an old Elm Stump, in a Smith's Cellar in the Haymarket, London," and further speaks of it as a branched Agaric, resembling the horn of a Reindeer.

Bulliard's (1782) fungus is not of the extreme type described by Blackstone and later by Bolton, and yet, in the form of stipe and pileus, is far from having the appearance of the typical plant. On the same plate with his *Boletus polymorphus* he shows, for comparison, the regular form under the name *Boletus Juglandis*.

Bolton (1789) describes at considerable length a similar fungus under the common name of "Rain-Deer Boletus." He says that this species, which he proposes to name *Boletus rangiferinus*, is the same as the fungus figured by Blackstone, and also the same as Hudson's *Clavaria Hypoxylon* var. *B.* There can be no doubt that it is the same as Blackstone described. Whether Hudson's *Clavaria* is also the same thing will probably remain questionable.

The specimen upon which Bolton's description is based was found growing upon an old log in the town of Leeds. His plate shows a plant with a much elongated, branching stipe, in some cases terminated by small, apparently abortive, pilei, while on others even these are lacking. Two of the latter display finger-like branches toward the ends. A few branches have fairly well formed pilei. All branches have their origin in a common base.

As Sowerby (1803) has pointed out, *Polyporus squamosus* is one of the most mutable species among European polypores. It is for this reason, he asserts, that Bulliard was justified in giving this form of the fungus the name he proposed. In his *plate* 266 Sowerby gives figures of both typical and rangiferoid forms of the species.

Hussey (1847), while discussing *Polyporus squamosus*, says

that monstrous specimens of *Polyporus*, prevented from natural expansion into true pilei, have been erroneously considered as distinct species, and variously named accordingly, and that *Boletus rangiferinus* is one of these.

Sowerby expresses the view that these branching forms with reduced pilei are but terratological representatives of the species. Personally I would be inclined to accept these opinions of Hussey and Sowerby were it not for the fact that this variety is apparently limited in its distribution to western Europe. No collection has thus far been reported outside of this restricted area. This limitation in a variety, when the species is widely distributed, would seem significant. While this variety may be merged with the species in time, I do not believe our present data are sufficient to permit such action.

3. *POLYPORUS SQUAMOSUS* (Huds.) Fries, var. **glaber** (Batt.)  
comb. nov.

*Agaricus squamosus glaber* Batt. Fung. Hist. 68, *pl.* 34,  
*fig. A.* 1775.

*Poria vaporarius* Pers. Obs. Myc. 2: 15. 1799.

*Boletus vaporarius* Pers. Syn. Fung. 546. 1801.

*Polyporus vaporarius* (Pers.) Fries, Syst. Myc. 1: 382.  
1821.

*Polyporus infundibuliformis* Rost. in Sturm. Deuts. Flora  
3: 37, *pl.* 17. 1831.

*Polyporus Rostkowi* Fries, Epicr. 439. 1838.

*Polyporus pallidus* Schulz. & Kalchbr. in Kalchbr. Ic.  
Hymen. Hung. *pl.* 38, *fig.* 2. 1877. Not Berk. 1856.

*Polyporus pennsylvanicus* Sumst. Jour. Myc. 13: 137.  
1907.

Pileus solitary to caespitose with several stipes connate at the base, subcircular to reniform, sometimes infundibuliform, 3–15 cm. broad, 0.5–2 cm. thick; surface smooth, without scales or fibrils, light tan, occasionally smoke-colored; margin thin, wavy, entire; context white to pallid, soft-fleshy to punky, fragile when dry, 0.2–1 cm. thick, of usually sparsely branched, thick walled hyphae, 3–9  $\mu$  in diameter; tubes white to yellowish, large, angular, favoloid, 2–6 mm. long, 1–2.5 mm. wide, edges of dissepiments thin, entire, lacerate or toothed, decurrent; stipe excentric to lateral, 2–5 cm. long, 1–2.5 cm. thick, pallid to

reddish with black stains, occasionally abruptly black, upper portion reticulated by the rudimentary, decurrent tubes; spores hyaline, elongate-ellipsoidal,  $11-16 \times 4-6$  ( $14 \times 5$ ), smooth; cystidia wanting.

TYPE LOCALITY: Rimini, Italy.

HABITAT: Wood of deciduous trees. Late spring and summer.

DISTRIBUTION: Rare in New York, Pennsylvania, Ohio: Rare in Europe.

ILLUSTRATIONS: Battarra, Fung. Hist. *pl.* 34, *fig.* A. 1775; Kalchbrenner, Ic. Hymen. Hung. *pl.* 38. 1875; Sturm, Deuts. Fl. Pilze 3: *pl.* 17. 1831.

Battarra (1775) first described this fungus as a glabrous variety of *Agaricum squamosum* Mich. It therefore becomes necessary, for reasons previously mentioned, to combine Battarra's varietal name with *Boletus squamosus* Huds.

American material is usually found solitary and ranges from 4-10 cm. in width, with a stipe 2-4 cm. long by 1-1.5 cm. thick that is more often pallid throughout but may become reddish with black stains. On the other hand European specimens, and especially those from England, are more often caespitose, approach the species in size and may have its definite black based stipe.

Peck (1879) has referred his New York material to *Polyporus pallidus* Schulz. & Kalchbr., while Lloyd (1911), who has examined the same specimens, says that they agree with his conception of *P. Rostkowii* Fries. This does not conform with the opinion of Bresadola (1931), who considers that *P. pallidus* is the same as the *aureus* form of the species. It would be difficult to agree with Bresadola after consulting Kalchbrenner's (1877) publication.

Fries (1838) recognized a definite relationship between his *Polyporus Rostkowii* and *P. squamosus*, and says in this connection, "Magnitudine cum affini *P. squamoso* certat."

4. POLYPORUS SQUAMOSUS (Huds.) Fries, var. **fagicola** (Murr.) comb. nov.

*Polyporus fagicola* Murr. Torreyia 6: 35. 1906.

Pileus circular to subcircular, convex to plane and umbilicate, 4-8 cm. broad, 0.1-0.5 cm. thick; surface smooth, light yellow-

brown to pale brown, with tufts of innate fibrils which are larger and darker near the center and more scattered toward the periphery, though sometimes almost wanting; margin very thin, slightly decurved, regular, not ciliate; context white, fibrous, 1-4 mm. thick, composed of hyphae 3-10  $\mu$  in diameter, usually thin walled but variable in this respect, when thin walled more frequently branching than when thick walled; tubes white or whitish, favoloid, 1-2.5 mm. long, 0.5-1.5 mm. wide, decurrent; stipe central to excentric, solid, thick, conspicuously hispid, particularly toward the base, 2-4 cm. long, 1-1.5 cm. thick, white or whitish, rarely brownish or darkened at the base, upper portion reticulate with decurrent tubes; spores hyaline, elongate-ellipsoid, 11-15  $\times$  4-5 (14  $\times$  4.5)  $\mu$ , smooth.

TYPE LOCALITY: Boarstone Mountain, Piscataquis County, Maine.

HABITAT: *Fagus grandifolia* Ehrh.

DISTRIBUTION: Maine, New York.

ILLUSTRATIONS: Lowe, Mich. Acad. Sci. **19**: pl. 15, fig. 3-4. 1933.

Murrill (1906, 1908) reports the spore size as 6-7  $\times$  3-4  $\mu$  in his original description and subsequent publication. This is much smaller than that of the spores of *Polyporus squamosus* and its varieties. I find, upon examination of Murrill's type material, however, the spore measurement to be 11-15  $\times$  4-5.5 (14  $\times$  5)  $\mu$ , in the case of mature spores, and hence comparable to those of the above named species. My findings agree in this respect with those already reported by Lowe (1934) who has also examined Murrill's type specimen. There is but one specimen of this fungus in the herbarium of The New York Botanical Garden. This is very evidently young material, and it seems possible that Murrill's error may have been due to an examination of spores from near the immature margin. Had the spores been found to vary as much as Murrill suggests there might be sufficient reason for considering this a distinct species. Without this the segregation seems unwarranted, and varietal standing more desirable.

Lowe (1933) believes the chief difference between *Polyporus fagicola* and *P. pennsylvanicus* to be in the absence of scales on the pileus and the larger pores of the latter species. He believes that *P. pennsylvanicus* should be placed in synonymy with

*P. fagicola* which he considers merely a diminutive form of *P. squamosus*. Lowe does not recognize the possibility of a closer relationship between *P. pennsylvanicus* and the forms included in the earlier synonymy as I have presented it in the present paper.

It seems to me that the purposes of taxonomy are better served by including *Polyporus pennsylvanicus* and the American forms previously recognized as *P. pallidus* or *P. Rostkowii* with the European glabrous forms. It may be granted that these are usually smaller in size than the members of this variety found in Europe, but the same may be said for American material of the species itself.

*Polyporus fagicola* varies from *P. squamosus* in its typically much smaller pileus, in the fact that its cap scales are reduced to hairs and in its smaller pores. It is in all respects, except with regard to spores, a diminutive variety of *P. squamosus*. It seems to me that *P. fagicola* has developed along a somewhat different line of divergence from the species than those forms which I have recognized as var. *glaber*, and should for that reason be kept distinct.

There is apparently another American form of *Polyporus squamosus* which is in need of investigation. Though I have seen but one collection of this variety, it appears to have such marked characteristics as to arouse one's curiosity. The specimens which I have observed have the diagnostic characteristics of the species except that the color of the upper surface is distinctly grayish as well as being radially striate. This material has the size, the surface scales, large favoloid pores and the dark based stipe of *P. squamosus*, but with a surface color suggestive of a quite different species provided the scales were removed.

*Polyporus arcularius* Batsch, with its brown, minutely scaly cap, favoloid tubes and dark brown stipe would seem to be remotely related to the smaller forms of *P. squamosus*. Its smaller spores and other varying characteristics prevent its inclusion here and indicate that it should be retained as a separate species.

The writer wishes to express his indebtedness to Dr. F. J. Seaver and The New York Botanical Garden for courtesies extended during the preparation of this paper.

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# A LEAF-SPOT DISEASE OF HONEY LOCUST CAUSED BY A NEW SPECIES OF LINOSPORA

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(WITH 2 FIGURES)

A fungus commonly designated as *Melasmia hypophylla* (B. & Rav.) Sacc. occurs on honey locust, *Gleditsia triacanthos* L., within the environs of Durham, North Carolina, and Athens, Georgia. From the records of collections it appears to be widely distributed throughout the southern United States. It is apparently restricted to this one host and does not appear on related leguminous plants.

The previous systematic position of this fungus has been within the family *Leptostromataceae* of the *Fungi Imperfecti*. It was first described as *Sacidium Gleditschiae*, in 1845, by L  veill   (7: 64) from specimens collected in Texas and deposited in the Museum of Paris. Subsequently, it was collected in South Carolina by Ravenel who sent specimens to Berkeley in 1855, and they designated it *Leptostroma hypophyllum* B. & Rav., but apparently they never described it. Ravenel distributed it under this name in *Fungi Caroliniana* fasc. III, no. 45. In 1888, specimens of this same fungus were communicated to Ellis and Everhart (3: 45) from Missouri, Kansas, and Louisiana, and it was again renamed, this time being assigned the binomial, *Melasmia Gleditschiae*. Saccardo (9: 419), in 1892, recognized that *Leptostroma hypophyllum* and *Melasmia Gleditschiae* are synonymous, but he was not aware that *Sacidium Gleditschiae* applies to the same organism, and in consequence employed *Melasmia hypophylla* (B. & Rav.) Sacc. as the name of this pathogene on honey locust. Seymour (10) employed *Melasmia Gleditschiae* (L  v.) Ellis & Ever. as the most acceptable name. Apparently, these brief mycological notes constitute all that has been published regarding this fungus during the period since 1845 when it was first described.

The writers' studies have been concerned with the structure of the pathogene, both conidial and perithecial stages, as a basis for determining its systematic position. The type of development of the organism, as determined by examination of infected leaves at intervals throughout the summer and fall, shows that it is questionable whether the conidial stage should be regarded as *Melasmia*. The perithecial stage, that matures in spring on decaying leaves, has not been described previously. The honey locust organism has been compared with European specimens of *Linospora Capreae* (DC. ex F.) Fuckel, the type of the genus *Linospora* on *Salix caprea*, and has been found to conform closely to it.

#### CONIDIAL STAGE

The fungus, in its conidial stage, can be recognized by the presence of numerous, flat, black fructifications upon the lower leaf surface. They may occupy the greater part of the lower leaf surface, or be densely scattered over it (FIG. 1, 2A). They vary in size from mere points to bodies 1 mm. in diameter. When discrete they are circular, and are irregular when several have coalesced. If the fructifications are examined with a binocular, irregular fissures, through which the conidia are liberated, are apparent. Tissues that are embedded in paraffin and viewed in vertical section (FIG. 2B) clearly show that the fruiting structures are subcuticular, and that the conidia arise from a thin palisade layer that is seated upon the epidermal cells. The cuticle of the leaf above the conidial stroma becomes distended as the mass of spores increases, and the pressure thus produced eventually causes the cuticle to rupture. The conidia are oblong, straight, or slightly curved, hyaline and non-septate, measuring  $3-5 \times 1-1.5 \mu$  (FIG. 2F). They are budded off singly from short conidiophores that form a compact palisade layer arising from the stroma.

This type of fructification is definitely not a pycnidium, but an acervulus. *Melasmia*, according to the generic concept, consists of a pycnidium within a stroma that opens with a longitudinal slit, and the spore layer is definitely inclosed by fungus tissue. In contrast with this, the acervulus of the honey locust fungus is composed of a parallel layer of conidiophores developing from a subhymenial stromatic layer. The layer comprising the cover of the

fruit body contains no fungous tissue but consists solely of the leaf cuticle. These morphological features place this imperfect stage within the order *Melanconiales*, family *Melanconiaceae*—*Hyalosporae*, and in the form genus *Gloeosporium*.



FIG. 1. Leaves of honey locust showing acervuli of the so-called *Melasmia* stage of *Linospora Gleditsiae*.

## THE PERITHECIAL STAGE

The perithecial stage was collected in 1933, and again in 1934, and appears to be mature throughout the period from the middle of May until the middle of August. It can be recognized by the blunt, cylindrical, perithecial beaks that project prominently, usually from the upper leaf surface of infected leaves found in moist places under the trees. There are from a few to approximately twenty, occurring singly or in pairs, on each leaflet. Leaves cut in vertical section show that the perithecia are embedded within the mesophyll, and that they are so large that the leaf is distended. The axes of the perithecia are parallel to the leaf surface, and the beaks are so bent as to be perpendicular to the leaf surface (FIG. 2C).

The perithecial initials were first seen within the mesophyll of leaf sections of material collected in December. At this time they consist of spherical masses of very fine hyphae inclosing larger elements in a rather loose center. During the winter the peripheral layer of hyphae expands rapidly. The divisions are chiefly tangential, resulting in the increase in diameter of the mass, without any apparent increase in the thickness of the wall.

The ostiolar neck begins as a vertical cone in the apex of the perithecium, and is directed toward the leaf center, rather than toward the leaf surface. Then, during the latter part of February and March, the wall cells proliferate inward forming a beak that bends upward during development and that finally pierces the epidermis. The perithecial wall now consists of very fine coalesced hyphae that course peripherally and into the tissue of the lateral beak. At maturity this beak measures from 0.5 to 1.5 mm. in length, and appears on the side of the leaf opposite that in contact with the soil.

At an early stage the perithecial centrum consists of true paraphyses with free ends pointing toward the upper center of the cavity. There is a continuation of these elements in the beak as the wall apex grows upward. Here, however, the threads are very much finer, and when the beak is mature they form the true periphyses of the ostiolar cavity. These periphyses, and the paraphyses on the upper wall adjacent to the opening, are perma-

nent, but those paraphyses interspersed with the asci are digested and disappear as the asci mature.

The ascogenous hyphae lie on the inner periphery at the base and sides of the perithecial wall. Their penultimate cells become the asci, which grow upward among the paraphyses. When mature, the asci are cylindrical, straight or curved, with no stipe, and inclose eight filiform ascospores (FIG. 2D). The bases of the asci are readily soluble in water, and in free hand sections the entire mass of asci separates, as in species of *Diaporthe*. The mature perithecial centrum consists of asci lining the base and sides, directed toward the lateral aperture of the ostiolar neck.

There is no fungous structure within the leaf that one could term a stroma or that appears like the coalesced hyphae which one finds in the *Xylariaceae*. The entire mesophyll of the leaf, however, contains a much branched hyphal system, both inter- and intra-cellular. These threads are dark, have extremely thick walls, and a very small lumen. Within the epidermal cells, they form a pseudoclypeus which is penetrated by the beak.

If the leaves are kept moist the asci are extruded in droplets at the tips of the beaks. This type of ascal discharge has been observed in several genera of long beaked Pyrenomycetes, and has been described by Ingold (5: 177), in the case of *Ceratostomella ampullasca* (Cooke.) Sacc. The asci are usually curved, and are provided with a thickened apical wall that is partly pierced by a tubular pore (FIG. 2D). The asci measure  $80-110 \times 10-15 \mu$ . The ascospores are filiform, hyaline, and  $70-90 \times 3 \mu$  (FIG. 2E).

Attempts to cultivate this organism on artificial media have thus far not been successful. Both conidia and ascospores have failed to germinate. When, however, in July 1934, leaflets bearing the perithecial stage were fastened to healthy leaflets, infection followed, and the conidial stage had developed within four or five weeks after inoculation. This demonstrates the genetic connection of the ascigerous and conidial stages.

The increase in the number of diseased leaflets, on trees that were observed at frequent intervals, indicates that the conidia must be capable of germination. It may be recalled that Jones (6: 41) suggested that the so-called conidia of *Rhytisma acerinum* may be spermatia instead of conidia.

## SYSTEMATIC POSITION OF THE FUNGUS

The presence of a special perithecial wall composed of fine hyphae that proliferate into a true ostiolar neck, and the presence of paraphyses and periphyses place the honey locust organism among the *Sphaeriales*. Those forms that appear similar to the fungus under consideration have no paraphyses and fall into one or the other of two developmental types. In one type, illustrated by *Dothidea collecta* (Schw.) Ell. and by species of *Mycosphaerella*, the asci grow upward and displace the parenchymatous tissue that comprises the center of the developing perithecium. In the other, illustrated by *Plowrightia morbosa* (Schw.) Sacc., and by members of the *Pleosporaceae*, the asci arise at the bases of parallel hyphae that are attached both at the top and bottom of the perithecial locule.

According to Clements and Shear (2: 59) the order *Sphaeriales* has family rank, *Sphaeriaceae*. In their *Scolecosporeae* (2: 74) those fungi with a clypeus, without paraphyses, and with a lateral beak, are included in *Linospora*; those without a beak are placed in *Ceuthocarpon*. The type of *Linospora* is *L. Capreae* (DC. ex F.) Fuckel, and of *Ceuthocarpon* is *C. populinum* Pers. ex Karst. The writers have examined European specimens of both species: Exsic. 735 Petrak Fl. Bohem. et Morav., *Linospora Capreae* (DC.) Fuckel on *Salix caprea*; and Exsic. 246 Syd. Myc. Germ. *Linospora populina* (P.) Schröt. on leaves of *Populus tremula*. Both contain perithecia with prolonged lateral beaks, a blackened layer in the epidermis surrounding the beaks, and periphyses in the ostiolum, but paraphyses that disappear at maturity. These two forms, therefore, are clearly congeneric, as is concluded by Lindau in Engler und Prantl (8: 452). According to the generic concept used in the classification of Lindau the fungus on honey locust should be placed in the genus *Linospora* Fuckel, but in the family *Clypeosphaeriaceae*.

Another possible relationship of our fungus is with the genus *Ophiodothella* v. Höhn. Boyd (1: 463) transferred this genus from the *Phyllachoraceae* of the *Dothideales* to the *Clypeosphaeriaceae*. This genus is similar to *Linospora* in having a clypeus, perithecial wall, ostiolum, and periphyses and paraphyses, but differs in having papillate ostiola rather than a beaked ostiolum, and in the

manner of development of the ostiola. In *Linospora*, the ostiole is lateral and then bends upward, while in *Ophiodothella* it begins in the center of the top of the developing perithecium and grows straight upward. This difference in the ostiolar neck is regarded as sufficient to maintain the two genera as distinct.

When the present aggregation of unrelated forms is rearranged according to phylogenetic relationships *Linospora* should be grouped with the *Diaporthaceae* v. Höhn. Here the asci have no definite stalks and when moistened contract and dissolve, thus freeing the asci from each other. The ascus walls readily dissolve in the *Diaporthaceae*. The paraphyses are delicate, numerous, and evenescent with age, but the periphyses remain. These characteristics represent the concept of von Höhnel (4: 631), and also that of Wehmeyer (11: 610). The *Clypeosphaeriaceae* and *Diaporthaceae*, as now understood, are separated mainly on the grounds that one occurs on bark, the other on leaves; and that the stroma is better developed in one than in the other. These do not appear to be adequate reasons for separation into two families.

The conidial stages in species of *Linospora* are not well known. The writers find no mention of conidial stages for *L. Capreae*, but *L. populina* has a *Gloeosporium* stage very much like that in *L. Gleditsiae*.

#### DESCRIPTION OF THE FUNGUS

The developmental morphology of the perithecial stage, as well as that of the conidial stage, definitely places this fungus in the genus *Linospora* Fuckel of the family *Clypeosphaeriaceae*. It is proposed that the organism under consideration be given a new name. It is briefly characterized as follows:

#### ***Linospora Gleditsiae* n. sp.<sup>1</sup>**

Syn. *Sacidium Gleditschiae* Lév. Ann. Sci. Nat. III. 3: 64.  
1845.

*Leptostroma hypophyllum* B. & Rav.

Exsic. Rav. Fung. Car. 3: 45. 1855.

Ellis & Ever. N. A. F. 2173. 1889.

Seymour & Earle, Econ. Fung. 123. 1892.

Ellis & Ever. Fung. Columb. 975. 1896.

<sup>1</sup> From data kindly supplied by Dr. Grant D. Darker, Farlow Herbarium, Cambridge, Massachusetts.



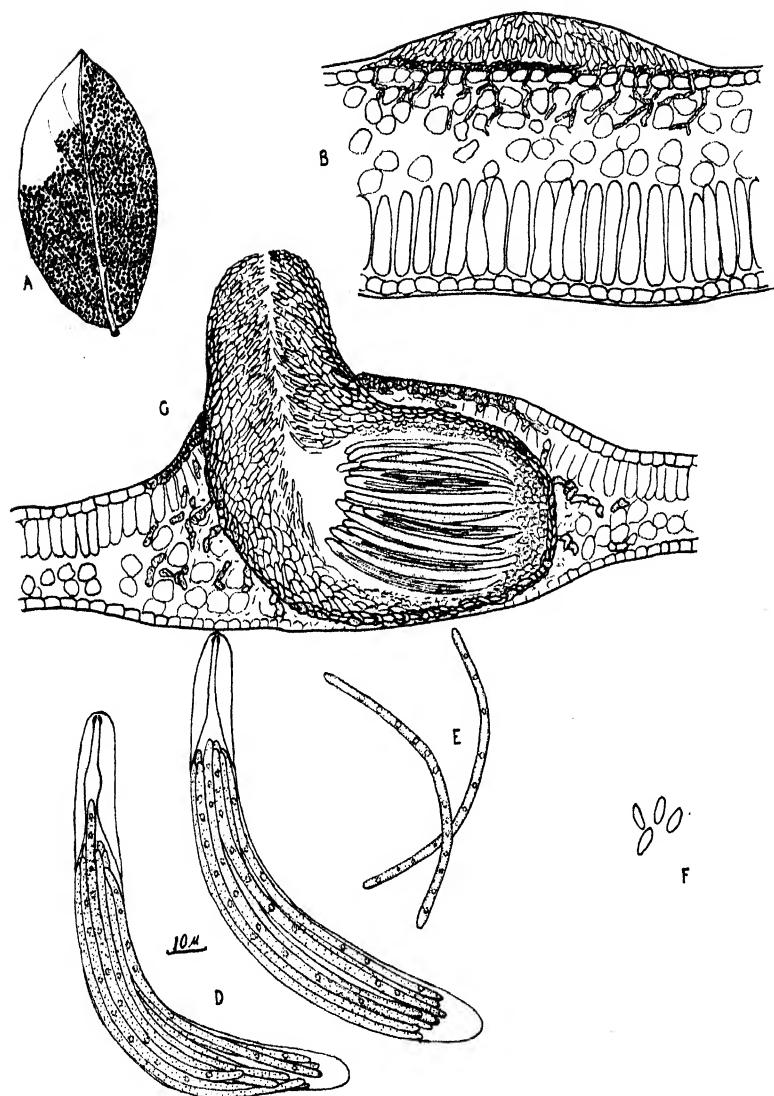


FIG. 2. A, diagram of leaflets showing the distribution of acervuli on the lower leaf surface; B, acervulus, in vertical section, formed between the epidermal cells and the cuticle; C, vertical section of the perithecium of *Linospora Gleditsiae* embedded within the mesophyll and with bent beak and asci parallel to the leaf surface; D, asci of *L. Gleditsiae*; they lack stipes and possess apical pores (D, E, and F drawn to scale shown near the asci); E, ascospores; F, conidia.

*Melasmia Gleditschiae* Ellis & Ever. Jour. Myc. 4: 45. 1888.

*Melasmia hypophylla* (B. & Rav.) Sacc. Syll. Fung. 10: 419. 1892.

Exsic. Pazschke Fung. Eur. 4196. 1898.

Kellerm. Ohio Fung. 102. 1903.

Kabat & Bubak Fung. Imp. 179. 1904.

Barthol. Ell. & Ev. Fung. Columb. 975. 2233 in index 26. 1910.

*Melasmia Gleditschiae* (Lév.) Ellis & Ever.

Exsic. Kellerm. & Sw. Kan. Fung. 10. 1889.

Roum. Fung. Gall. 5039. 1889.

Wilson & Seaver. Ascom. 13. 1907.

Peritheciis sparsis, vulgo solitariis, folia pustulatim inflantibus, atris, procumbentibus, elongatis, rostris exsertis, atque curvulis; mycelio fusco in stratis epidermidis pseudoclypeum formante; rostris conicis, perithecio aequantibus vel longioribus; peritheciis in medio mesophyllio immersis; centrum peritheciae primitus ex paraphysibus atque ascibus constitutum, paraphysibus in ostiolo, deinde paraphysibus disparentibus; ascis numerosis, sessilibus, oblongo-cylindraceis curvulis, 8-sporis, poro distincto praeditis, apice ostioli liberatis vel in aqua separabilibus,  $80-110 \times 10-15 \mu$ ; ascosporis filiformibus, hyalinis deinde virentibus, curvatis, poro liberatis vel parietibus basilaribus in aqua solutis,  $70-90 \times 3 \mu$ .

Hab. in foliis dejectis atque putrescentibus *Gleditsiae triacanthi*, in terra.

Status conidicus: Acervulis hypophyllis, maculam fuscobrunneam occupantibus, dense punctiformibus, minutis vel 1 mm. diam.; orbicularibus vel irregularibus, subcuticularibus, atris; conidiis oblongis, rectis v. curvulis, continuis, hyalinis,  $3-5 \times 1-1.5 \mu$ . Parasitice in foliis vivis, in aestive et autumne, *Gleditsiae triacanthi*.

Type specimens have been deposited in the Farlow Herbarium, Harvard University, Cambridge, Massachusetts.

#### SUMMARY

The conidial stage of a fungus of common occurrence on the foliage of honey locust has been known as *Melasmia hypophylla*. Its fructification is an acervulus and not a pycnidium, and it belongs in the form genus *Gloeosporium*.

The perithecial stage, described as *Linospora Gleditsiae* develops on diseased leaves that have overwintered. Evidence of genetic connection of the two stages is based upon the development of the conidial stage on leaves that were inoculated, using

leaves bearing perithecia as inoculum. Attempts to grow *Linospora Gleditsiae* in culture, either from ascospores or from conidia, have been unsuccessful.

It would seem that the genus *Linospora*, although in the *Clypeosphaeriaceae*, should better be placed nearer members of the *Diaporthaceae*.

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## A NEW PSEUDODISCOSIA<sup>1</sup>

RODERICK SPRAGUE AND A. G. JOHNSON<sup>2</sup>

(WITH 2 FIGURES)

In 1932 a small amount of an unfamiliar leaf spot on Winter Turf oats (*Avena sativa* L.) was found by the senior writer in the Alsea River Valley, Oregon. In February 1934, the disease was found again and more abundantly on the same host on High Prairie, near Lyle, Klickitat County, Washington (5). The attacked plants were somewhat dwarfed, and an abundance of reddish brown spots of various sizes and shapes occurred on the leaves. In addition, the plants also showed considerable reddening aside from the leaf spots. A more detailed description of the development of the disease has been given elsewhere (6). Numerous conidia were found on the lesions and these spores were used in isolating the fungus on potato-dextrose agar. The spores germinated readily at 4° C. and invariably produced very scanty growth. At the end of 6 weeks the colonies were barely visible to the unaided eye. At a magnification of 100 times, the colonies could be seen to consist of hyaline hyphae, which clung closely to the surface of the agar. At intervals on the hyphae, a profusion of conidia were borne in fan-shaped whorls, usually laterally or less commonly at the end of short branches. All transfers from these colonies failed to grow.

On examining cross sections of the spore-bearing lesions, it was found that the spores were produced on very short conidiophores compacted together on a poorly developed stroma in the epidermis (FIG. 1). There was no apparent rupture of the leaf epidermis as in typical acervuli. The fungus was considered as

<sup>1</sup> Coöperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon and Washington Agricultural Experiment Stations.

<sup>2</sup> Assistant pathologist and principal pathologist, respectively, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

belonging to the Melanconiales and to the genus *Pseudodiscosia* Hösterman and Laubert.

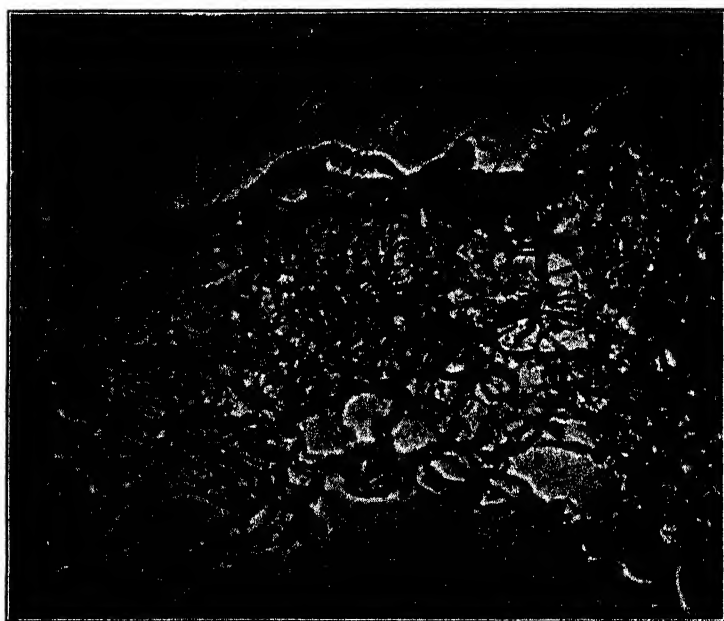


FIG. 1. Cross section of a leaf of *Avena sativa* through a lesion caused by *Pseudodiscosia Avenae*. The fungus occurred throughout the interior of the leaf but was most abundant near the upper surface. Location of the conidiophores and developing spores are indicated by arrows. The section was made by aid of a freezing microtome.  $\times 145$ .

The type species of *Pseudodiscosia* is *P. Dianthi* Hösterman and Laubert, which causes an important leaf rot of carnation in Europe (3). Salmon and Ware (4) accepted the name given by Hösterman and Laubert, but Buddin and Wakefield (1), after finding that the fungus had a pycnidial form, transferred the species to the genus *Heteropatella* Fuckel.

The fungus on oats differs from *Heteropatella Dianthi* in that the acervuli are less distinct and the conidia are narrower. The length of the conidia, their septation, general form, and the way they are borne on the conidiophores are very similar in the two fungi. Therefore, while they are clearly distinct from each other, apparently they are closely related.

In 1929, Gizhitskaïa (2) described *Heteropatella graminis* on dry grass stems in Russia. The original description of this fungus is quoted in full as follows:

"Pseudopycnidiis superficialibus, fragilibus, 250-300  $\mu$ , diam., atris; conidiis hyalinis, 50-60/4-4, 5  $\mu$ , elongato-cylindraceis, apice rotundatis, 10-12-septatis, in setam 50-62, 5/1, 5-2  $\mu$  elongatis.

"Ad culmum siccum graminis. Kiovia. In Horto Botanico. 16. X. 1928."

The fungus on oats differs from *Heteropatella graminis* in that the acervuli of the former fungus are less distinct and the spores have fewer septae and are somewhat narrower and considerably shorter than those of the latter fungus.

Thus the fungus on oats differs from both *Heteropatella Dianthi* and *H. graminis* and therefore is here described as a new species. As no pycnidial stage has been found for the fungus on oats, it logically belongs in the genus *Pseudodiscosia*.

### ***Pseudodiscosia Avenae* sp. nov.**

Mycelium branched, septate, hyaline to faintly tinged with yellow, intracellular or intercellular in the leaf, aggregating at or near the surface, more frequently the upper surface, producing blunt or rarely sharp-pointed 1 to 3-celled (mostly 1-celled) conidiophores 5 to 12 by 0.8 to 2  $\mu$ . Conidia with one cilium at each end. Body of spore narrowly fusiform, slightly curved, hyaline or faintly tinged with yellow, 2 to 3 septate, 10 to 42  $\times$  2 to 4  $\mu$  (FIG. 2). Conidia are borne singly or sometimes in pairs, acrogenously or subacrogenously. Bases of spores are rounded or blunt with a rod-shaped or sometimes sharp-pointed appendage or cilium, 1 to 16  $\times$  0.3 to 1.3  $\mu$ , attached obliquely near the hilum. The apical appendage or cilium usually is longer than the one at the base and usually merges very gradually with the body of the spore.

Mycelium ramosum, septatum, hyalinum vel dilute flavidulum; conidiophora in stromate basilare nascentia, obtusa vel acuta, non septata vel 1-2-septata, 5-12  $\times$  0.8-2  $\mu$ ; conidia utrinque appendiculata, fusiformia, hyalina vel dilute flavidula, 2-3-septata, 10-42  $\times$  2-4  $\mu$ , singulatim vel interdum binatim acrogena vel subacrogena, basi rotundata vel obtusa; appendicula basilaris, oblique prope hilum affixa, 1-16  $\times$  0.3-1.3  $\mu$ , appendicula apicalis plerumque longioris.

On leaves of fall-sown oats (*Avena sativa*) in the Alsea Valley,

Lincoln County, Oreg., February 1932, and High Prairie, Klickitat County, Wash., February 1934, forming fawn to dark brown lesions, which are sometimes more or less diffuse and sometimes with red borders. Frequently only the distal halves of the leaves are affected. The affected portions are rather leathery. Attacked plants were somewhat stunted and showed excessive reddening.

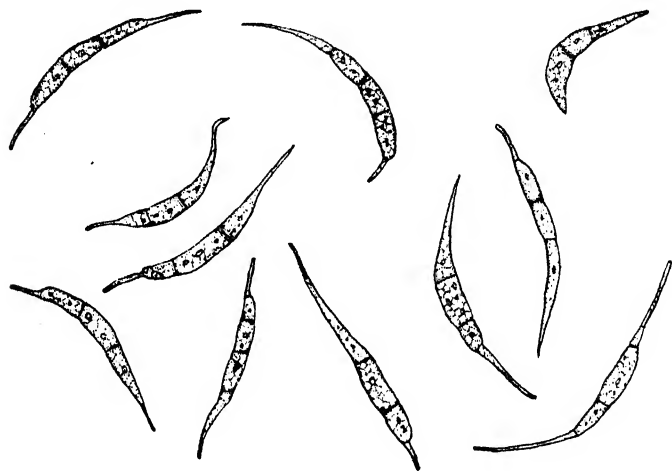


FIG. 2. Conidia of *Pseudodiscosia Avenae* drawn with the aid of a camera lucida.  $\times 750$ .

Co-type specimens have been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, and the herbaria of the Department of Botany, Oregon State College, Corvallis, Oreg., Department of Plant Pathology, Washington State College, Pullman, Wash., Department of Plant Pathology, University of Idaho, Moscow, Idaho, Department of Botany, University of Wisconsin, Madison, Wis., and The Herbarium, Kew, England.

The writers are indebted to Miss Edith K. Cash, assistant pathologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, U. S. Department of Agriculture, for assistance in preparing the Latin description.

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## PHOTOGRAPHS AND DESCRIPTIONS OF CUP FUNGI—XXIII. STAMNARIA

FRED J. SEAVER

(WITH 1 FIGURE)

In August, 1934, Dr. J. J. Davis of Wisconsin sent the writer specimens of a fungus on *Thuja occidentalis*, which was not recognized by him. Neither was it known to the writer, and since no fungus had been reported on this host, which seemed to fit, it was decided to publish it as new.

The generic limits of the cup-fungi are not very well defined. After considerable study it has been concluded that this is a *Stamnaria* resembling very closely *Stamnaria Equiseti*. The apothecia occur in erumpent, congested clusters and are extremely gelatinous, shrinking to almost nothing in dried material. A description follows:

### **Stamnaria Thujae** sp. nov.

Apothecia occurring singly or more often in congested masses erumpent through the epidermis on the under side of the foliage of the host, translucent with a slight yellowish or pinkish tin exceedingly soft and gelatinous, shrinking much in drying, the individual apothecia small, not usually exceeding .2 mm. in diameter; asci clavate, reaching a length of  $55\ \mu$  and a diameter of  $15\ \mu$ , 8-spored; spores irregularly disposed in the ascus, ellipsoid hyaline, granular  $6-7 \times 10-12\ \mu$ ; paraphyses very slender branched.

Apotheciis gregariis, erumpentibus, hypophyllis, tremelloideis, hyalinis vel subroseis, .2 mm. diam.; ascis clavatis, octosporis  $15 \times 55\ \mu$ ; sporidiis ellipsoideis, granulosis, hyalinis,  $6-7 \times 10-12\ \mu$ ; paraphysis filiformis, ramosis.

On foliage of *Thuja occidentalis*.

TYPE LOCALITY: Baileys Harbor, Wisconsin.

DISTRIBUTION: Known only from the type locality.

THE NEW YORK BOTANICAL GARDEN,  
BRONX, NEW YORK CITY

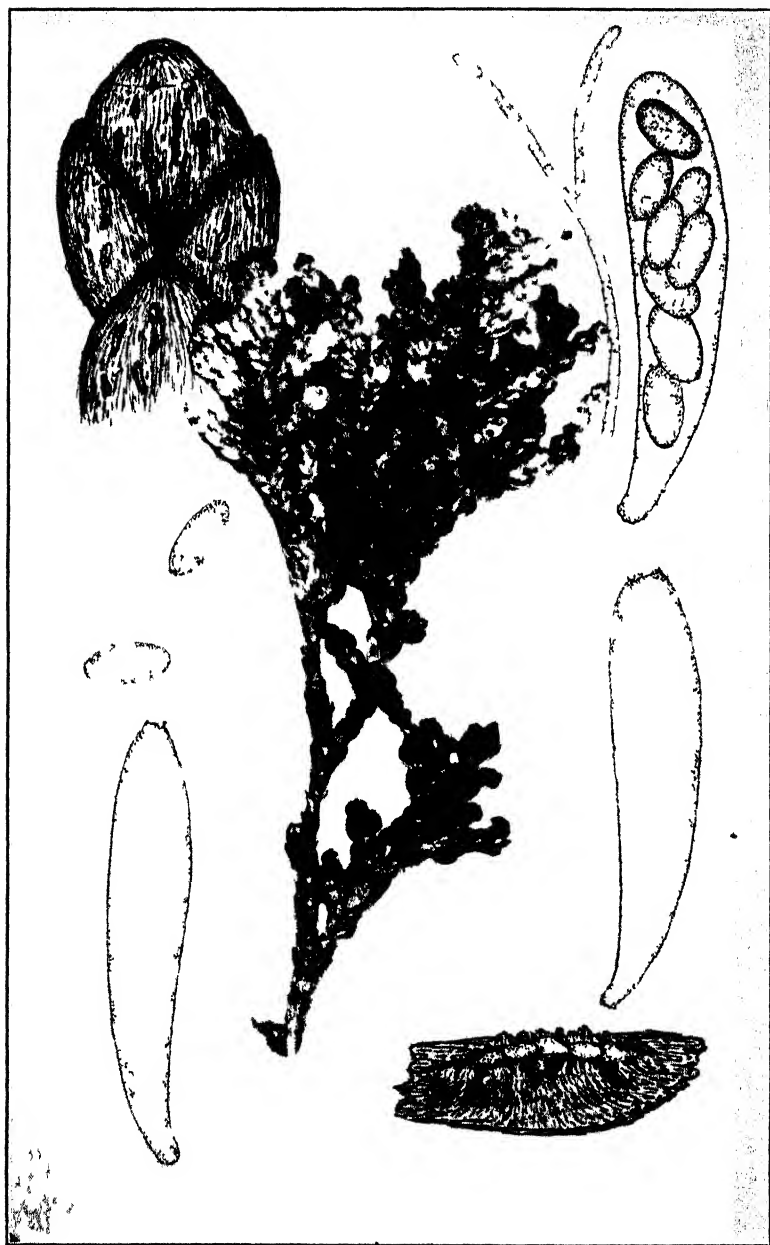


FIG. 1. *Stannaria Thujae* Seaver.

# THE MORPHOLOGY AND DEVELOPMENT OF CALICIOPSIS PINEA

HELENE WALLACE MCCORMACK<sup>1</sup>

(WITH 21 FIGURES)

The genus *Caliciopsis* Peck (9) was described by its author as a member of the Discomycetes. Rehm (10), Arnaud (1, 2), and other students of the taxonomy of the Ascomycetes have agreed with Peck, and in general have placed the genus near *Calicium* of the Caliciaceae. Ellis (4, 5) regarded *Caliciopsis* as essentially identical with his own pyrenomycetous genus *Hypsotheca*, but in deference to Peck's opinion did not merge the two. Fitzpatrick (6) included the species of *Hypsotheca* in *Caliciopsis*, incorporated the genus in the Coryneliaceae, and expressed the opinion that the family is pyrenomycetous and most closely allied to the Perisporiaceae. Influenced by the work of Miller (7), he has since come to regard the fruit-body in *Caliciopsis* as not a true perithecium, but as more of the nature of a loculate stroma such as exists in the Dothideales and allied orders. As no one of these divergent points of view has been based on a cytological and ontogenetic study, it has seemed desirable that one be made. In the investigation here reported, emphasis has been placed on the determination of the method of origin of the ascigerous cavity and ostiolar opening, and on a study of the initiation and development of the layer of asci.

The type species of the genus *Caliciopsis*, *C. pinea* Peck, is found on the trunks and branches of *Pinus Strobus* and has been reported also on other coniferous hosts. It is not uncommon throughout the northeastern United States, and occurs abundantly in central New York. The material used in this investigation was collected at Ringwood Wild Life Preserve near Ithaca,

<sup>1</sup>The writer gratefully acknowledges the assistance and suggestions of Doctor H. M. Fitzpatrick under whose direction this work was undertaken and prosecuted. A summary of the investigation was presented by him at the winter meeting of the Mycological Society of America at Pittsburgh, Pa. in December, 1934.

New York, in the latter part of April 1934. Ascigerous fruit-bodies in all stages of development were found on the bark of *Pinus Strobus* in the typical, smooth, depressed cankers mentioned by Fitzpatrick (6: 226) and Overholts (8: 235) as characteristic of the disease apparently caused by this fungus. In addition the less conspicuous bodies referred to tentatively by Fitzpatrick as pycnidia were collected. Our studies indicate that they are instead spermagonia.

#### PREPARATION OF MATERIALS

The best preparations of the spermagonia obtained were made by free hand sectioning of the diseased bark. The sections were stained by warming them gently in lacto-phenol and methyl blue. The excess stain was then removed and mounts were made in 50 per cent glycerine.

Ascarps of various ages, after being removed from the bark and softened by soaking in warm water for several hours, were placed in chrome-acetic acid fixer for twenty-four hours. The material, after washing, was carried into paraffin through butyl alcohol and studied in serial sections 6 to 10  $\mu$  in thickness. In staining the material a modification of Heidenhain's iron alum haematoxylin method was used, in which a 1 per cent solution of picric acid is substituted for iron alum in differentiation.

#### MATURE STRUCTURES

The mycelium of *C. pinea*, as it exists in the cortical tissue of the host, is composed of long, narrow, cylindrical cells. Small, more or less circular, often confluent stromata are formed beneath the outer layer of the bark by the aggregation of the mycelial elements. In early stages these stromata give little external evidence of their presence, but continued growth of the hyphal mass finally causes the rupture of the bark. The small, cushion-shaped stroma, thus exposed, soon takes on a lobed appearance, and in time the lobes develop into spermagonia and ascarps.

The spermagonium is small, black, and pycnidium-like (FIG. 1). At maturity it measures 100–150  $\mu$  in diameter and comes to be filled with rod-shaped to allantoid hyaline or slightly yellowish, single-celled spermatia measuring 2.5–3.5  $\mu$  and produced on



FIGS. 1-8. *Caliciopsis pinea* Peck on bark of *Pinus Strobus*.

bottle-shaped or conical spermatiphores. A small but definite ostiolar opening is present.

The mature ascocarp (FIG. 3), which appears to the unaided eye as a small black spine, is a stromatic column with an apical or sub-apical enlargement containing a single ascigerous locule. Spermatogonia are often found clustered about the base of the column. The surface of the ascocarp is dull to shiny. In texture it is coriaceous, becoming more or less gelatinous when moist. The elongated stroma measures 1.75–2.5 mm. in length, is cylindrical, straight or somewhat curved, often swollen at the base and occasionally branched, producing in such cases two or more apical ascigerous swellings.

The asci (FIG. 21) are ovate,  $12\text{--}19 \times 5\text{--}8 \mu$ , with long slender stalks, and contain eight small, ellipsoidal to nearly globose, golden-brown ascospores. The spores are freed by the deliquescence of the ascus wall and are pushed out through the opening, giving the tip of the stromatic column a distinctly reddish-brown, fuzzy appearance.

#### DEVELOPMENT OF THE SPERMAGONIUM

Formation of the cavity of the spermatogonium is initiated at the center or toward the apex of a short stromatal lobe by disintegration of the hyphae of that region (FIG. 4, 5). The cavity, thus formed, continues to enlarge through progressive disintegration of the hyphae of the lobe until much of its central tissue disappears. Long thread-like, vacuolated hyphae (FIG. 6) persist for a period in the cavity, but organization of a definite hymenium soon takes place, and finally the cavity is filled with spermatia (FIG. 7) which escape to the outside through a definite ostiolar opening (FIG. 8). Before the cavity is fully formed rather large unicellular, bottle-shaped to conical spermatiphores appear at its border and cut off small rod-shaped to allantoid spermatia. They are slightly smaller than those later developed in the cavity from spermatiphores of essentially the same type.

Similar cases of spermatogonia in which two sorts of spermatia are produced have been reported by Dodge (3: 747). In both *Guignardia Bidwellii* and *Phyllostictinia carpogena*, according to him, two types of spermatia occur, but those of the first kind

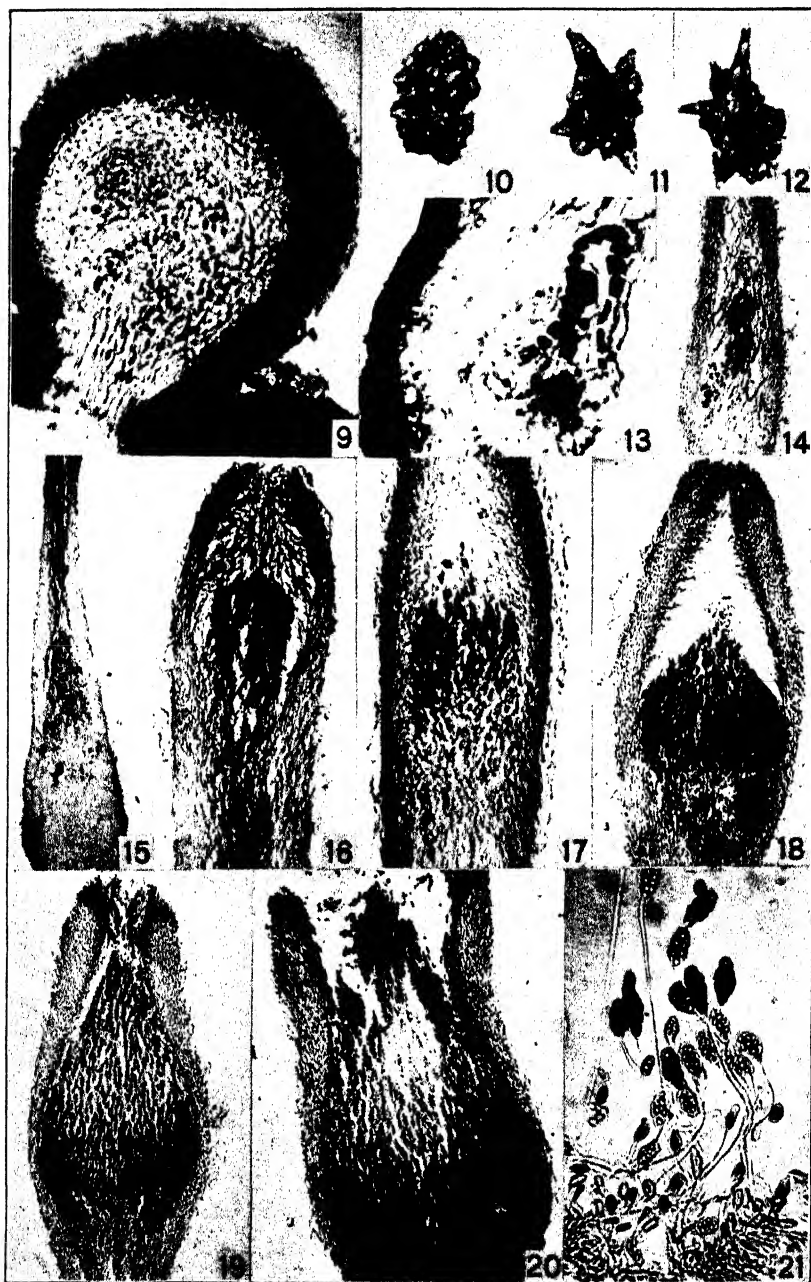
formed are not borne on definite spermatophores. Instead they result from the disjunction of the cells of thread-like hyphae which fill the cavity in its early stages. Later, as in the case of *C. pinea*, when definite spermatophores have come to be present, the cavity is devoid of these thread-like aggregations. The reason for the existence of the two types of cells is not clear. In *C. pinea*, several unsuccessful attempts were made to germinate them. This failure of germination has led us to regard both of them as spermatia.

#### DEVELOPMENT OF THE ASCOCARP

In their early stages the spermatogonium and ascocarp, developing together from neighboring lobes of the cushion-shaped stroma, are superficially indistinguishable (FIG. 10). However, in section the two are seen to be different. The lobe (FIG. 9) which is destined to develop into an ascigerous stromatic column reveals in section no cavity, but instead homogeneous tissue in which lie deeply staining hyphae of the nature of archicarps.

The lobe of the stroma in which these archicarps occur (FIG. 13) soon begins to elongate and assumes a conical form (FIG. 11, 12). At this stage its hyphae are long, narrow, and branching and form a more compact peripheral layer enclosing a central core of looser tissue in which the archicarps lie (FIG. 14). As the lobe elongates into a sharp-pointed spine (FIG. 2) the hyphae in its base take on a vacuolate aspect and the walls of adjacent hyphae tend to coalesce (FIG. 15) giving a homogeneous appearance. Meanwhile the cells of the archicarps lose their contents and become less evident. A long bundle of ascogenous hyphae constitutes a core in the center of the rapidly elongating apical portion of the spine. Although the point of origin of these ascogenous hyphae was not traced definitely to the cells of the archicarp such a connection was clearly indicated by the sequence of events.

As the apical region of the column begins to swell, and differentiation of the ascigerous locule is initiated, a profuse branching of the ends of the ascogenous hyphae occurs (FIG. 16). Beyond their tips the hyphae composing the interior of the stroma loosen up and disintegrate to form a definite cavity (FIG. 17, 18) above the developing young asci. Meanwhile, the hyphae composing the outer layers of the stroma become more compact, and their



FIGS. 9-21. *Caliciopsis pinea* Peck on bark of *Pinus Strobus*.



walls tend to coalesce as do those at the base of the column in earlier stages. The continuation of lysigenous action at the tip of the stroma results in the formation of the definite opening (FIG. 18) through which the ascospores later escape (FIG. 19).

It will be noted that several archicarps arise in a single ascocarp and present the appearance of a gnarl of large-celled deeply staining hyphae in contrast to the lighter staining hyphae surrounding them. Each archicarp appears to be formed by the transformation of a single multicellular hypha, the cells of which become dense with protoplasm and increase in diameter until they are much broader than the stromatic cells. As the stromatal lobe elongates the archicarp becomes a looser coil, but the number of cells composing it is not easily determined on account of the irregularity and twisting of the several interwoven archicarps.

At the maturity of the archicarp the central cells, having continued to increase in diameter are three to four times the width of the smaller cells and from ten to twelve times that of the stromatic hyphae.

In one section only, a multicellular hypha was seen originating directly from an archicarp, penetrating the tissue of the ascocarp, and reaching the outside. Whether or not hyphae such as this constitute a trichogyne-like apparatus through which fertilization takes place cannot be asserted with certainty. The material was found to be not well suited for cytological investigation, the nuclei being very minute.

At the time that the asci are taking origin from the tips of the ascogenous hyphae (FIG. 17) and are pushing upward to fill the locule (FIG. 18, 19), it becomes evident that the fungus is not discomycetous in type. Paraphyses are absent and there is no palisade arrangement of asci to form a definite hymenium. Instead the asci are seen to compose a broad fascicle in which the individuals stand at every possible height. The ascus is borne on an extremely delicate stalk (FIG. 21) and these stalks in some cases are sufficient in length to extend from the base of the locule to its apex. In longitudinal section the base of the locule sometimes has the aspect of being lined with a palisade layer of young asci (FIG. 19, 20). This is, however, an illusion resulting from superficial observation, the band in the lower part of the locule being in

fact composed of the delicate stalks of asci, whose spore-bearing sacs are to be found throughout the entire interior of the locule. The fasciculate arrangement of the asci, clearly pyrenomycetous in type, is well revealed at higher magnification in figure 21. The ascospores are finally freed from the ascus by deliquescence of the ascus wall and lie free in the uppermost region of the locule. The entire mass of spores tends to cling together, and is pushed upward by the pressure of the developing asci below. Finally the pore which was formed by lysigenous action at the apex of the locule is greatly enlarged as the accumulation of spores bursts through and protrudes beyond the tip of the column as a fuzzy brown plug (FIG. 3). The nearly wide-open aspect which results provides the fungus with its single evidently discomycetous character, and has led Arnaud (1, 2) to place *Caliciopsis* near *Calicium*. A consideration of our own observations, here presented, would seem to indicate that the genus falls instead near the Coryneliaceae, as suggested earlier by Fitzpatrick (6). In any case it is clearly a stromatic genus in which the ascigerous cavity is a locule.

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## EXPLANATION OF FIGURES

*Caliciopsis pinea* Peck on bark of *Pinus Strobus*

Photographs by W. R. Fisher. Fig. 1, caespitose clusters of spermatogonia,  $\times 10$ ; 2, spine-like stromatic columns, some of them beginning to form the apical enlargement in which the ascigerous locule lies,  $\times 10$ ; 3, mature ascocarps, the apices fuzzy from the extruded mass of ascospores and asci; spermatogonia visible at the base,  $\times 14$ ; 4, longitudinal section of a stromatic lobe which has begun to develop into a spermatogonium; the central cells disorganizing to form the spermatogonial cavity,  $\times 380$ ; 5, longitudinal section of a similar lobe in which the hymenium of spermatophores has been initiated,  $\times 380$ ; 6, section of a young spermatogonium showing vacuolated hyphae lining the enlarging cavity; spermatium-like cells of the first type present,  $\times 380$ ; 7, section of a mature spermatogonium almost completely filled with spermata, the vacuolated hyphae having disappeared from the cavity,  $\times 380$ ; 8, longitudinal section of a spermatogonium showing the ostiolar opening at the apex,  $\times 380$ ; 9, rather thick, free-hand, longitudinal section of a stromatic lobe which has begun to develop into an ascocarp; in its interior the deep-staining elements of developing archicarps evident and cavity formation lacking,  $\times 380$ ; 10, 11, 12, early stages in ascocarp formation, the hemispherical stromatic lobes beginning to elongate and assume the aspect of spines,  $\times 25$ ; 13, a group of archicarps surrounded by the tissue of the stromatic lobe,  $\times 380$ ; 14, archicarps evident at the center of a young elongating stromatic spine,  $\times 75$ ; 15, a bundle of ascogenous hyphae arising from the region of the stroma occupied by the archicarps and constituting a core in the elongating spine,  $\times 75$ ; 16, longitudinal section of the apex of the stromatic column showing the much branched tips of the ascogenous hyphae forming a deep-staining mass in the basal portion of the developing locule,  $\times 215$ ; 17, a somewhat later stage in which ascus-formation has begun, and lysigenous action has broken down the stromatic elements to give a locule,  $\times 215$ ; 18, the locule definitely outlined in the enlarged apex of the stromatic column, and the broad fascicle of developing asci filling its base,  $\times 215$ ; 19, the locule filled with asci, and provided apically with a definite pseudo-ostiolum formed by disintegration of the stroma at that point,  $\times 215$ ; 20, the pressure of asci and ascospores from below resulting in the enlargement of the ostiolar opening and the extrusion of the ascospores as a mass which has been in part washed away in the process of the preparation of the slide,  $\times 260$ ; 21, a group of asci removed from the ascocarp and photographed to show the fasciculate arrangement and the long delicate stalks,  $\times 380$ .

## NOTES AND BRIEF ARTICLES

### THE MYCOLOGICAL SOCIETY OF AMERICA

#### Report of the Fourth Annual Meeting

The fourth annual meeting of the Mycological Society of America was held December 31, January 1, at St. Louis, Missouri, in conjunction with that of the American Association for the Advancement of Science. The Society was represented on the Association Council by Fred J. Seaver and Carroll W. Dodge. The headquarters of the Society were at the Hotel Statler. This hotel served also as headquarters for the Botanical Society of America, American Phytopathological Society, and other botanical groups. The sessions of the botanical societies were held at Washington University. Registration was at the Municipal Auditorium. Arrangements for the Mycological Society were made by the local representative, Carroll W. Dodge.

The retiring president, Bernard O. Dodge presided at the sessions and gave as his address a paper entitled "Facultative and Obligate Heterothallism in Ascomycetes." As retiring vice-president of Section G. of the A. A. A. S. he gave a paper on "Reproduction and Inheritance in Ascomycetes." The Society held the usual joint sessions with Section G and the American Phytopathological Society. At the regular sessions a smaller number of papers than usual were presented, but some were of outstanding interest.

At the business session the election of new officers for 1936 was announced as follows: Harry M. Fitzpatrick, president, A. H. Reginald Buller, vice-president, David H. Linder, secretary-treasurer, Bernard O. Dodge, councilor. The council named Frederick A. Wolf to serve an additional five-year term as associate editor of MYCOLOGIA. The roll of the Society for 1936 now includes approximately 350 names, and the membership is slowly growing.—H. M. FITZPATRICK, *Secretary-Treasurer*

**Atractobasidium Grandinia** (Rick) comb. nov.

Through the kindness of Dr. Gladys E. Baker of the Henry Shaw School of Botany, my attention has been called to the description of *Platygløea grandinia* Rick, *Egatea* 18: 211. 1933, and I have been permitted to examine an authentic specimen, determined by Rick, in the collection of the Missouri Botanical Garden. It proves to be identical with the species described as *Atractobasidium corticioides* Martin, *Bull. Torrey Club* 62: 340. 1934. As stated in the latter reference, the fungus is not a *Platygløea*, but since Rick's specific epithet has precedence it is necessary to propose the new combination *Atractobasidium Grandinia* (Rick).—G. W. MARTIN.

## KEY TO THE BOLETACEAE

The Rhode Island Botanical Club has published a pamphlet entitled "Tentative Keys to the Boletaceae of the United States and Canada," by Walter H. Snell. As suggested by the title, these keys are not a final product, but, as the result of several years of study, represent the progress made to date in eliminating much of the confusion that has prevailed in this family in this country. It is believed that these keys will enable collectors of the higher fungi to identify with some degree of certainty the boletes they find, instead of ignoring them or putting them away without notes and unnamed even tentatively, as apparently has too commonly been the case in recent years.

In addition to the keys, this treatment contains four pages of "Aids to Rapid Identification," by the use of which difficult or ambiguous choices in the keys may occasionally be clarified, or identifications reached in short order by the narrowing of possibilities. For example, three of the headings in this section are—"Pileus with no red," "Flesh peppery to taste" (one species), "Spores under 8  $\mu$  long" (5 species named).

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## BRITISH STEM- AND LEAF-FUNGI

This volume by W. B. Grove is devoted to the Sphaeropsidales to the end of the Sphaerioideae which have colorless or nearly colorless spores. The Fungi Imperfecti, or Deuteromycetes, are divided into two large groups: (1) those which bear their spores within some cavity of the matrix on which they grow, to which the author of this book gives the name Coelomycetes; and (2) those which bear their spores outside the matrix, which have long been known as Hyphomycetes.

It is the colorless spored forms which Grove is considering in the present volume. In the larger genera, such as *Phyllosticta*, the species are arranged on the basis of host characters in alphabetical order. Each species is accompanied by a brief description of the diagnostic characters. These are accompanied by notes on its relationship, or possible relationship, to other species. The imperfect fungus is included even though the perfect is known. Also suspected connection with a perfect stage is noted.

A number of new species are described, with Latin diagnoses in the back of the volume. A few text figures accompany the descriptions. The volume (i-xx + 1-488) is printed in the United States and may be secured through the Macmillan Company, New York, for seven dollars (\$7.00).—F. J. SEAVER.



# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVIII MAY-JUNE, 1936

No. 3

## PATHOGENICITY AND CULTURAL EXPERIMENTS WITH *CALICIOPSIS* PINEA<sup>1</sup>

W. W. RAY<sup>2</sup>

(WITH 6 FIGURES)

The ascomycetous fungus, *Caliciopsis pinca* Peck, is apparently not uncommon in eastern North America on white pine, *Pinus Strobus* L. It has been observed frequently on this host in the region of Ithaca, New York, during the past fifteen years. It occurs also on a number of other coniferous hosts, and has been found in western North America and in Europe. On white pine it is often associated definitely with sharply delimited cankers on the trunk and larger branches. Fitzpatrick (1920: 226), who discusses the species taxonomically in his monograph of the Coryneliaceae, states that the fungus is parasitic and the cause of the formation of the cankers. He emphasizes the fact, however, that his statement is based wholly on field observations and is unsupported by results of artificial inoculations. Overholts (1930: 235) also says that the fungus is parasitic, and states that small saplings have been noted by him to die where no other

<sup>1</sup> The substance of this paper was presented before the Mycological Society of America at its annual winter meeting at Pittsburgh, Pennsylvania, December 27, 1934, by Professor H. M. Fitzpatrick.

<sup>2</sup> The writer wishes to express his appreciation to Professor H. M. Fitzpatrick for suggesting and supervising this investigation.



agency that might have been responsible for their death could be found. The importance of white pine as a forest tree makes the study of the disease of special significance, and, as adequate proof of the parasitic nature of the fungus had not been provided, the inoculation experiments, here reported, were undertaken.

On white pine the fruit bodies of *C. pinca* are found on the surface of cankers of two quite distinct types. Those of the type which in our experience is the most common are round depressed areas in the cortical tissue (FIG. 2). They are sharply delimited, and their characteristically reddish-brown color, contrasting with the gray background of the normal bark, renders them visible at a considerable distance from the tree. Though often small, they may attain individually a diameter of several inches and are frequently confluent (FIG. 3). Large branches and even the trunk may thus be completely encircled. Though these cankers are commonly rather superficial, the injury is sometimes deep enough to involve the cambium. The other type of canker was first mentioned by Overholts. In this case the canker occurs "in most pronounced form just below the branch whorls" and bears a "resemblance to the extreme roughening of the bark caused by the pine woolly aphid." Apparently it is in connection with the formation of cankers of this type that the greatest injury to the tree results. We have often observed the fruit-bodies of *Caliciopsis* on the surface of the roughened bark at the axils of the branches of living and dead trees, though definitely delimited cankers have not in all cases been distinguished. Doctor George H. Hepting of the Division of Forest Pathology of the United States Department of Agriculture in a letter to Doctor Fitzpatrick alludes to the tendency of *Caliciopsis* to fruit on the roughened bark at the axils of the branches in white pine and states that he examined one tree about ten feet high which had about half of its twigs under one inch in diameter apparently killed by this fungus. He states further that he has observed *Caliciopsis* throughout the Appalachian Mountain Region from Maryland through Georgia where it occurs commonly on *Pinus Strobus*, *P. echinata*, and *P. virginiana*.

Many of the small, sharply delimited, reddish-brown cankers formed on white pine are devoid of fungus fruit-bodies of any



FIGS. 1-6. *Caliciopsis pinea*.

kind. Not infrequently, however, the surface of the canker bears the small erumpent, black stromata of *Caliciopsis*. As the stroma develops, small hemispherical lobes appear over its surface. Many of these lobes undergo further development to form flask-shaped spermagonia containing small hyaline spermatia. Others elongate into spine-like columns (FIG. 5), which are destined to contain the asci and spores. As the column approaches maturity it enlarges at the apex, and within the enlargement a single ascigerous locule is developed. The column is black and glabrous and attains a maximum length of 2 mm. (FIG. 6). The apical swelling containing the ascigerous locule may collapse in drying and have a compressed aspect. During the late winter and spring, the asci mature their spores. The tip of the column finally opens by an indistinct pore through which the ascospores are extruded. They tend to adhere in a mass about the opening in the form of a powdery brown plug which is at length disintegrated by wind and rain. The spores are unicellular, subglobose, and light brown.

Cultures of the fungus were obtained from ascospores by the dilution plate method. Also small bits of cortical tissue taken from the edges of cankers and planted in agar plates gave rise to pure cultures of the fungus. The cultures derived from the spores were identical in every respect as to cultural characteristics with those obtained from the diseased tissue.

*Inoculations.*—Small pieces of agar bearing the mycelium of these cultures were inserted in tiny slits made in the bark of healthy white pines under conditions previously rendered as sterile as possible. In other cases a heavy spore suspension was employed, a few drops being inserted in similar slits in the bark. Also a number of slits were made to serve as checks, no fungus material being inserted. All of these cut areas were kept covered for a week with moist absorbent cotton. These inoculations were made in the spring of 1934. By the autumn of the same year well defined reddish-brown, sunken areas, identical in aspect with the cankers commonly observed on white pine were present where inoculations had been made. During the spring of 1935 stromata appeared on several of these. Spermagonia have formed on these stromata, but no stromatic columns containing ascospores have appeared as yet in August, 1935. Thus, it is evident that from

the time of inoculation to the formation of spermatogonia and stromatic columns a period of considerable length has elapsed. No cankers were found in any of the controls.

As a result of these artificial inoculation experiments, the conclusion seems warranted that *Caliciopsis pinca* is parasitic on white pine and the cause of the typical cankers above described. Judgment as to the importance of the disease in the nursery and forest must be deferred until more extensive field studies have been made.

Additional inoculations have been performed during the spring of 1935 on other coniferous trees in an effort to gain additional information concerning host range, but not enough time has elapsed to warrant evaluation of the results.

*Cultural characteristics.*—Since no account concerning the culture of this fungus was found in the literature, experiments dealing with the growth, cultural characteristics, and production of spermatogonia and stromatic columns have been performed.

It is a simple matter to remove ascospores with the point of a needle from the apex of the stromatic column, but they have a tendency to cling together in clusters, probably because of the gelatinous layer which surrounds each spore. Attempts to separate the spores in connection with the pouring of dilution plates were not wholly successful. At least, there was no certainty that individual spores had been obtained. To make sure of getting single spores, use of the micro-dissection apparatus proved necessary. Single spores, isolated with it, were placed in nutrient broth in sterile depressed slides and allowed to germinate and grow until the mycelium filled the drop of broth. Then with a needle the mycelium was transferred to agar plates.

A number of media were tested in the effort to find one upon which the fungus would grow and produce fruit-bodies. The mycelium grew slowly on 2 per cent potato-dextrose agar, oat meal, malt, beef, cornmeal, and media made with the decoction obtained by boiling white pine bark or wood. The growth on cornmeal was slightly more vigorous than on any of the other media used. On cornmeal small brown bodies appeared in the depths of the medium and to a lesser degree on its surface. These bodies occurred singly or in small clusters and gradually became darker. When mature they were found to be spermatogonia containing minute spermatia.

The mycelium grew very slowly, seldom filling a 100 millimeter petri dish within a period of eight weeks, and formed a very tough mat on the surface of the agar which was cut with difficulty. There was far less mycelial growth within the depths of the media. The color of the colony varied from a buff to a dark brown, and often a zonate appearance was given by the presence of dark and light bands. Microscopic examination revealed in many cases the fusion of several hyphal elements to form rhizomorph-like strands. Because, on cornmeal, growth was good and spermatogonia were produced abundantly, this medium was adopted for all further work. Many plates were planted with single spore, polyspore, and canker tissue isolates. Within four to eight weeks spermatogonia appeared in all the plates. Those on the surface exuded white drops of spermatia. Although several such series were run using cornmeal agar alone, no stromatic columns were produced, even when artificial spermatization was performed.

It was suggested that if blocks of white pine bark, sterilized in the autoclave, were placed in plates of cornmeal agar the spermatogonia might be formed on the surface of the wood where spermatization could take place more favorably. Hence, such blocks were placed in petri dishes, and agar was poured in and allowed to solidify around them in such a way that only their upper surface was left exposed.

Single spore isolates were planted in these plates in pairs in all possible combinations, a planting being made on each side of the oblong pine block. Plates containing only one of the single spore isolates were also made, as well as single isolates from cankered tissue. Within six weeks the mycelium had grown well, and along the exposed surface of the bark, where the mycelium of the two plantings met, there was formed a line densely covered with spermatogonia. A smaller number of spermatogonia were found on both sides of this definite line. The spermatogonia were small, flask-shaped to globose bodies occurring singly or in groups on a branched structure. White opaque drops of spermatia oozed from the spermatogonia (FIG. 4). No attempt at artificial spermatization was made, and eventually the cultures dried without having formed mature stromatic columns.

Another series of plates similar to those mentioned above was made. To one set of these, when the spermatia were oozing, was added sterile distilled water. This was agitated, and allowed to remain covering the culture for several hours, after which the excess was poured away. To the other set of plates no water was added.

Several weeks later in one plate containing a pair of single spore isolates, there appeared structures comparable to the stromatic columns produced in nature (FIG. 6). These arose among the spermagonia, and formed in a definite line (FIG. 1). In duplicate plates made with the same two single spore isolates, some of which were spermatized artificially, while the others were not, stromatic columns appeared in a few plates of each kind, but not in every plate. In only two of the many plates just mentioned were ascospores produced. The remaining plates dried out before maturity was attained.

In some of the other plates containing other isolates singly or paired, structures resembling stromatic columns appeared but did not mature.

Repetition of these experiments gave similar results, but in none of the plates did the columns which were produced become wholly mature and spore bearing. The fact that the columns reached maturity in only two cases of the many trials may be due to the long time required by the fungus for fruiting, and because of the difficulty experienced in preventing drying out and contamination of the cultures.

#### SUMMARY

1. Inoculations with mycelium and spores from pure cultures have demonstrated that *Caliciopsis pinea* Peck is parasitic on white pine and causes the formation of sharply delimited cankers on the trunk and branches.

2. In pure culture spermagonia and mature stromatic columns containing asci and spores have been developed.

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## LITERATURE CITED

1. **Fitzpatrick, H. M.** Monograph of the *Coryneliaceae*. *Mycologia* 12: 206-267. 1920.
2. **Overholts, L. O.** Mycological Notes for 1928-1929. *Mycologia* 22: 232-246. 1930.

## EXPLANATION OF FIGURES

Photographs by W. R. Fisher. Fig. 1, stromatic columns forming a definite line on a block of white pine surrounded by cornmeal agar in a petri dish,  $\times 2\frac{1}{4}$ ; 2, rounded cankers on white pine, the narrow sinuous white lines being due to the work of insects, nat. size; 3, small cankers on white pine coalesced to form larger cankers, nat. size; 4, clusters of spermagonia produced in culture showing exuding drops of spermatia,  $\times 13$ ; 5, a portion of a small canker on the surface of which are groups of spermagonia and stromatic columns, the white area being due to the exudation of resin,  $\times 2$ ; 6, some of the mature stromatic columns produced in culture on the blocks of white pine bark,  $\times 9$ .

## RELIQUIAE KAUFFMANI

JOHN DEARNESS

When the late Dr. C. H. Kauffman was overtaken by his last illness there remained a number of his collections undetermined. About sixty of them were submitted to me for examination including thirteen which are here described as new species.

The collections were made by Dr. Kauffman himself except where otherwise stated. Compared co-types were returned to be deposited in the herbarium of the University of Michigan. The descriptions are arranged in the order adopted in Clements and Shear's *Genera of Fungi*.

### ASCOMYCETES

#### **Trematosphaeria cornina** Dearn. sp. nov.

Perithecia evenly but not thickly scattered, cartilaginous, black, shining, usually 0.66 mm. in diameter, embedded in the cortex, subglobose, somewhat flattened above but ascending to the short, wide ostiolum about  $120\mu$  above the surrounding level of the bark without rupturing it, appearing clypeate. Asci very variable, averaging  $125 \times 15\mu$ , range  $105\text{--}140\mu \times 12\text{--}36\mu$ , thick-walled sometimes up to  $10\mu$  at the top; densely paraphysate. Ascospores one to eight in an ascus, brown, elliptic with narrowed ends, 4-6-celled, variable in size, the largest in asci with few spores,  $24\text{--}38 \times 12\text{--}20\mu$ , obliquely uniseriate or biseriate or irregular.

On dead branches of *Cornus* sp.; Harlan, Ky.; Sept. 6, 1916. (D. 8077b.)

#### **Curreya Corni** Dearn. sp. nov.

Stromata grayish pustules with black centers, 1-1.25 mm. in diameter, rising above the bark level about 0.5 mm., bulging the bark to half their height and then rupturing it into a close fitting collar. Locules 1-3 in a stroma, internally black, shining, if single nearly globose, short necked, 0.5-0.7 mm. in diameter. Asci soft, transparent, evanescent, variable in shape and size, usually



8-spored, reaching  $150 \times 30 \mu$  in a mass of indefinite paraphysoids. Ascospores brown, muriform, uniseriate or irregularly biseriate, oblong-elliptic, contracted towards the ends but not acutely, varying from  $21 \times 12$  to  $66 \times 18 \mu$  with 1-8 transverse septa and 0-3 longitudinal septa shorter than the ascospore.

On dead, 1 cm. thick branches of *Cornus* sp.; Harlan, Ky.; Sept. 6, 1916. (D. 8077.)

**Euryachora Neowashingtoniae** Dearn. sp. nov.

Stromata black, shining, rough, clypeate, intracuticular, circular with a single locule and then about  $300 \mu$  in diameter, or subcircular with 2-3 locules and about 1 mm. in diameter, often confluent and irregular. Loculi  $75-225 \mu$ , one to several in a stroma, breaking the clypeus into a stellate or irregular rupture. Asci not numerous, globose,  $42 \mu$  in diameter or variously saccate,  $105-30 \mu$  when nearly oblong, 8-spored; paraphysate. Ascospores hyaline, mucous-sheathed, 1-septate, constricted, upper cell usually rounder than the lower one,  $20-28 \times 9-10.5 \mu$ .

On dead petioles of *Neowashingtonia filifera* var. *robusta*; Miami, Fla.; Feb. 11, 1919. (D. 8064.)

**Hysteropsis guajava** Dearn. sp. nov.

Hysterothecia in the wood surface, shining black or dull black when thinly covered with fibers, cleft most of their length,  $125-500 \mu$  parallel to the fibers,  $50-120 \mu$  in width. Asci cylindric, clavate or saccate, thick-walled, stipitate or almost sessile,  $35-85 \times 10-17 \mu$  varying with the seriation of the ascospores and the length of the stipe, shorter usually than the paraphyses. Ascospores hyaline, muriform, oblong-elliptic, with 3-5 transverse septa and one partial longitudinal septum,  $15-18 \times 8-9 \mu$ .

On decorticated wood of a living guava tree,—*Psidium guajava*; Miami, Fla.; Feb. 24, 1919. (D. 8078.)

## PHOMATALES

**Phoma Anemones** Kauff. sp. nov.

Pycnidia thinly scattered, subcuticular, ostiolate,  $120-160 \mu$  in diameter, hemispheric to subglobose, arising from brownish or amber colored hyphae. Conidia hyaline, bacillar, some of them

curved,  $5-6.5 \times 1.25 \mu$ , on filiform conidiophores produced from relatively deep plectenchyma.

On dead stems of *Anemone virginiana*; Ann Arbor, Mich.: June 6, 1920. (D. 8069.)

Dr. Kauffman had proposed this name; his notes are incorporated. *Phoma regina* Fairman inhabits *Anemone* but its conidia are of different shape from these.

**Naemosphaera pinicola** Dearn. sp. nov.

Pycnidia scattered, long-beaked, superficial, subglobose, dark brown or black under the lens, membranous, thin-walled,  $120-130 \mu$  in diameter; beak  $0.6-1.5$  mm. long, very narrow,  $90 \mu$  thick at the base gradually reducing to  $50 \mu$  at the top where it bears a short, hyaline sheath. Conidia numerous, pale brown, subelliptic,  $7-8 \times 4-5 \mu$ .

On pine shavings in a saw-dust pile; Ann Arbor, Mich.; May 15, 1929. Coll.: R. McArdle. (D. 8080.)

**Sphaeropsis cornicola** Dearn. sp. nov.

Pycnidia very thickly scattered, black, showing the small ostiola through a cruciform rupture of the epidermis,  $0.3$  mm. in diameter, connected by branching brown hyphae in the cortex. Conidia pale brown, oblong with rounded ends, contents homogeneous,  $15-17 \times 6-7 \mu$  on obscure, narrow, short conidiophores.

On dead branchlets of *Cornus* sp.; Cabin John, Md.; Dec. 12, 1918. (D. 8068.)

**Rhabdospora Arctii** Kauff. sp. nov.

Pycnidia thickly scattered, black, subcuticular,  $80-140 \mu$  in diameter,  $45 \mu$  deep, wall thin; ostiola cylindric,  $15-30 \mu$  long. Conidia hyaline, straight,  $19-21$  (24)  $\times 0.8-1 \mu$  on short conidiophores up to  $15 \mu$  long; hymenial layer  $30 \mu$  thick.

On dead stems of *Arctium minus*; Ann Arbor, Mich.; June 6, 1920. (D. 8073.)

**Camarosporium Ceanothi** Dearn. sp. nov.

Pycnidia thickly scattered, low, small, black pustules,  $150 \mu$ , rupturing the epidermis by a narrow cleft. Conidia hyaline at first

becoming amber brown, 1–3 septate, usually muriform, on conidiophores up to  $12 \times 1.25 \mu$ .

On dead twigs of *Ceanothus americanus*; Takoma Park, Md.; June 13, 1918. (D. 8062.)

Associated with perithecia containing immature asci,  $15 \times 3.75 \mu$ , without paraphyses.

**Cornularia harpographoides** Dearn. sp. nov.

Pycnidia or synnemata on large, laminated lenticels, mostly in a circle near the edge of the lenticel, rarely on the unbroken bark, black, nearly smooth, 0.75–1.25 mm. in height,  $150 \mu$  thick at the base,  $75 \mu$  thick near the top just below the slight capitulum. Conidia hyaline, narrowly crescentic, ends acute, 1–3 septate,  $28\text{--}35 \times 3\text{--}3.5 \mu$ , the septation made visible by staining; conidiophores fasciculate-branching,  $1\text{--}1.25 \mu$  thick.

On what appears to have been living or languishing branches of *Crataegus* sp.; Jackson, Mich.; July 13, 1917. (D. 8065.)

Dr. Kauffman's note reads "on scale insects." I found the pycnidia only on large lenticels with an exceptional one on the bark.

**Cornularia Populi** Dearn. sp. nov.

Pycnidia thickly scattered, black, shining, superficial, subgelatinous, membranous, columnar, contracting upwards, sometimes from an enlarged basal portion, usually single, perforate at apex, sometimes clustered and connate at the base suggesting a valsoid group of ostiola, 0.7–0.9 mm. long and where single  $140\text{--}180 \mu$  thick at the base and  $60\text{--}90 \mu$  at or near the top, internally lined with conidiophores. Conidia hyaline, linear, but somewhat thickened in the middle, obscurely 1-septate,  $10\text{--}11.5 \times 1\text{--}1.4 \mu$ ; conidiophores linear about one and a half times the length of the conidia.

On firm, decorticated, dead poplar,—*Populus* sp.; Ann Arbor, Mich.; June 9, 1909. (D. 8085.)

**Neopatella Kauffmani** Dearn. sp. nov.

Pycnidia thinly scattered, black, wall brown-cellular under magnification, subglobose, umbilicate, rough, becoming patellate with a stellate or irregularly divided border, erumpent,  $250\text{--}350 \mu$  in diameter, rising about  $100 \mu$  above the bark. Conidia hyaline, con-

tinuous, homogeneous or guttulate, evenly or falcately crescentic, exceptionally semi-circular, acute at the ends, sometimes obtuse at one end,  $21-32 \times 5-7 \mu$ , on short conidiophores,  $2-3 \mu$  wide.

On dead branches of *Fraxinus americana*; Rock River, Mich., near Lake Superior; Aug. 30, 1927. (D. 8088.)

## MELANCONIALES

### **Septogloeum parasiticum** Kauff. & Dearn. sp. nov.

Acervuli scattered on living branchlets up to 6 mm. thick under an epidermal covering about  $75 \mu$  deep, their position indicated by minute ruptures which in this collection are usually surrounded by whitish pulverulence of exuded conidia, 1 mm. in the longer diameter of the base, the portion of median vertical sections which react to eosin stain  $225 \mu$  in depth of which  $30-35 \mu$  is the thickness of the conidiophore layer. Conidia hyaline, oblong with rounded ends, granular, 3-septate when mature,  $28-52 \times 12-15 \mu$ , exuding in slightly pinkish pulverulence; conidiophores of various lengths,  $10-45 \times 3 \mu$ .

In the cortex of *Ulmus americana*, causing the shriveling of the leaves and the death of affected branchlets; in swampy ground north of Eloise, Mich.; June 2, 1917. (D. 8084.)

The name was proposed by Dr. Kauffman; his notes are incorporated in the description.

## SOME AUSTRALIAN HETEROBASIDIO- MYCETES

G. W. MARTIN

(WITH 2 FIGURES)

Through the kindness of Professor J. B. Cleland, of the University of Adelaide, I have been permitted to examine twenty-six collections of Australian Heterobasidiomycetes, mostly from South Australia, a number of which proved to be of unusual interest. Among the common and widespread species represented were *Exidia glandulosa* Fries, *Tremella frondosa* Fries, with brownish spores and basidia (*Phacotremella* Rea) and *Exidia nucleata* (Schw.) Burt. Of the last-named species there were no less than six collections, all from South Australia, suggesting that this species may be as common there as it is in temperate North America. All of these species are mentioned in Dr. Cleland's recent publication<sup>1</sup> but certain of them call for special comment.

SEBACINA (*Bourdotia*) MEGASPORA Martin. In Cleland, Larger Fungi of S. Austr. 334. 1935 (FIG. 1: 1-12). The description is printed in English in the work cited, without Latin diagnosis. It seems advisable to amplify the description and to append a Latin diagnosis and figures showing the microscopic characters.

Fructificatio ceracea, effusa, 1 cm. lata, gregaria, fuliginea vel subavellanea, in sectione 600-1000  $\mu$  crassa, ex hyphis 1.5-2  $\mu$  crassis densis contextis constituta; gloeocystidia frequentia, ex hyalino lutescentia, 30-60  $\times$  6.5-7.5  $\mu$ ; probasidia subglobosa, 18-28  $\mu$  diam.; basidia longitudinaliter septatis; sporae hyalinae, simplices, uno latere depressae, 24-30 (-38)  $\times$  11-14 (-16)  $\mu$ .

Effused in small associated patches, each up to 1 cm. in extent, soft waxy, thin, somewhat cerebriform, dark grayish brown to dingy watery drab and semitranslucent and 600-1000  $\mu$  thick when soaked, drying to a dull, blackish brown film; hyphae slender, 1.5-2  $\mu$  in diameter, intricately branched and anastomosing, with

<sup>1</sup> Cleland, J. B. Toadstools and mushrooms and larger fungi of South Australia. Part II. Adelaide. 1935.

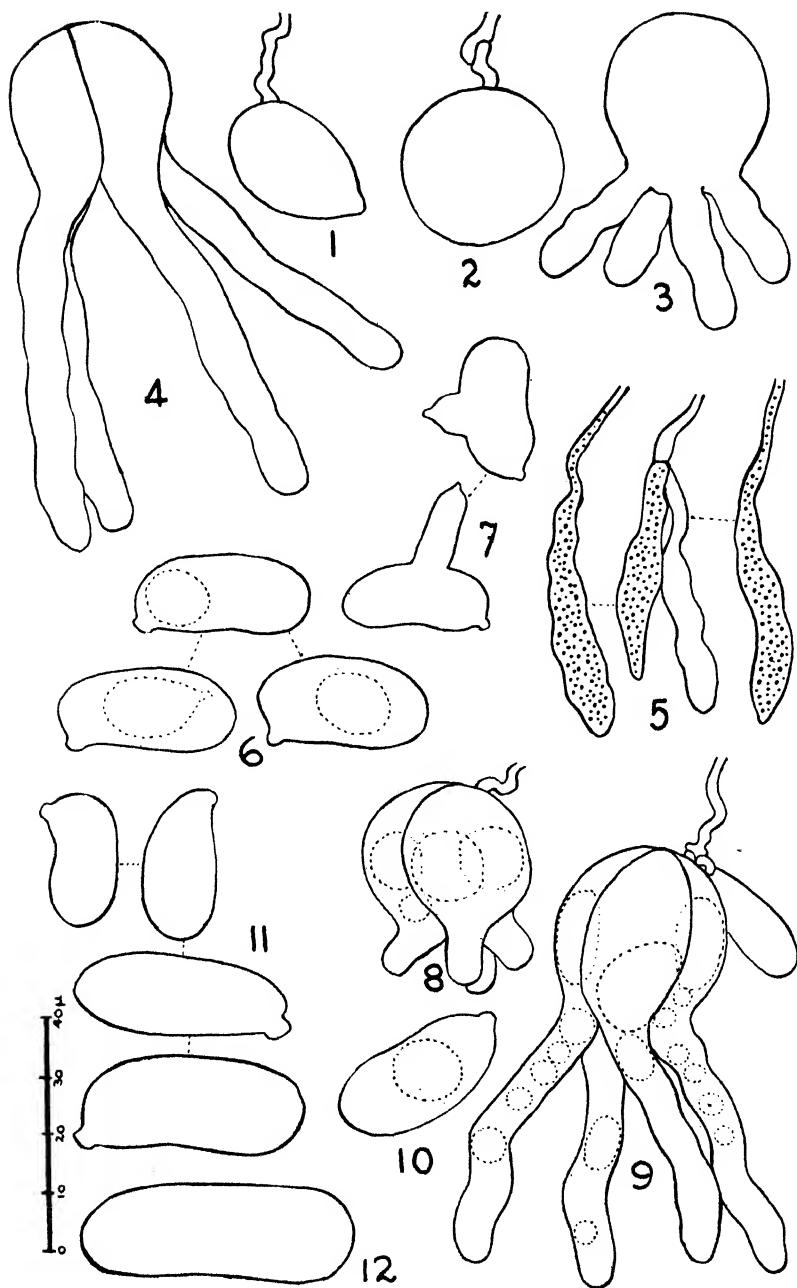


FIG. 1. *Sebacina megaspora*.

frequent clamp connections, immersed in a uniform gelatinous matrix; gloeocystidia abundant, at first hyaline, then yellow and filled with granular material, subcylindrical or clavate, tortuous, relatively small, mostly  $30-60 \times 6.5-7.5 \mu$ , and restricted to the dense brown surface layer above the probasidia; probasidia at first broadly ovate, then spherical, born on slender tortuous branches and soon detached,  $18-28 \mu$  in diameter, finally longitudinally septate into 2-4 cells, each of which produces an epibasidium  $50-90 (-150) \times 4.5-7 \mu$ ; spores hyaline, cylindrical, depressed on one side, or subballantoid, with a conspicuous, blunt apiculus,  $24-30 (-38) \times 11-14 (-16) \mu$ , germinating by repetition.

Specimens examined:

South Australia: National Park, July 28, 1923, J. B. Cleland 43, **type** (in herb. State Univ. Iowa); Mt. Lofty, June 18, 1932, J. B. Cleland 39; June 13, 1925, J. B. Cleland 24.

Represented by three collections, from two localities. Strikingly different from all other species of the subgenus by reason of its extremely large basidia and spores. A few spore-like bodies without apiculi were seen whose size was considerably greater than that of the largest clearly defined spores. These bodies appeared to belong with the fungus, but their exact nature could not be determined. One such, measuring  $45 \times 17 \mu$ , is shown in figure 1:12. The apiculus of the spore is unusually large, even for a tremellaceous fungus. It is to be expected that a basidium of average size, divided into only two cells, would produce larger spores than one divided into four cells, and since such basidia are common, they probably account for the larger of the spores seen, while some of the smaller spores may be the result of successive germinations by repetition. A few very small basidia were seen which had divided into two cells, the septum being in most cases nearly or quite transverse. No such small basidia were seen which had produced epibasidia. In general, the probasidia become divided before the epibasidia begin to develop, but some basidia were observed with the epibasidia well advanced and no trace of the longitudinal walls (FIG. 1:3). The hyphae upon which the basidia are borne are curiously slender, and the basidia frequently appear to be completely detached from them, this circumstance having no perceptible effect upon their development.

## SEISMOSARCA HYDROPHORA Cooke (FIG. 2: 1-3).

Represented by seven collections. Cooke's original description (Grevillea 18: 25. 1889) is both inadequate and incorrect, as noted by Lloyd (Myc. Notes 5: 629. 1917; see also Letter 62, Note 431. 1916). Cooke mistook *Peniophora*-like spores sprinkled on the fungus for the spores of his *Seismosarca*. Lloyd found a similar spore on one of his specimens, also received from Dr. Cleland, and one of the seven collections here discussed had a large number of such spores sprinkled on it. Nevertheless they were certainly not produced by the *Seismosarca*. The true spores of the latter fungus are present in abundance in all the collections. They are hyaline, not pale yellow as Lloyd states, oval or short cylindrical, only rarely slightly allantoid, and  $12-15 \times 6.5-8.5 \mu$ , germinating by repetition. Since the microscopic structures of the species have never been illustrated, I include camera lucida sketches of basidia, basidiospores and gloeocystidia.

This species raises again the perplexing question of generic limitations in the Tremellaceae. The common American species *Seismosarca alba* Lloyd is certainly congeneric with the Australian species. Burt (Ann. Mo. Bot. Garden 8: 366. 1921) transferred the American species to *Exidia* with the comment: "it seems unnecessary and a great pity to segregate already small genera on the basis of every positive character which would make a species noteworthy." This is sound taxonomic doctrine. If *Seismosarca alba* were the only species in the genus, the fact that it has gloeocystidia, even added to the fact that its spores are not quite those of an *Exidia* and its texture is decidedly different, might be regarded as scarcely justifying its maintenance in a separate genus. The existence of the obviously closely related *S. hydrophora*, however, complicates the situation, since that species shows many points of similarity to certain species included in the subgenus *Bourdotia* of *Sebacina*, particularly *S. Pululahuana*, from which it is separated mainly by its lobed or somewhat cerebriform habit. In both species here referred to *Seismosarca* the basidiospores germinate by repetition, which is not an *Exidia* character, nor is the surface layer of thick-walled, interlacing hyphae present, noted by Wheldon (Mycologia 27: 54. 1935) as characteristic for *Exidia*. Under



the circumstances it seems desirable to maintain the genus *Seismosarca* as a useful, if perhaps temporary category. Although Lloyd pointed out Cooke's errors, he failed to publish a revised diagnosis of the genus. I therefore suggested an emended diagnosis which Dr. Cleland published under my name in the work cited (p. 331). *S. hydrophora* must, of course, be the type.

*SIROBASIDIUM SANGUINEUM* Lag. & Pat. (FIG. 2: 4-7).

Originally described from Ecuador in 1892 (Jour. Bot. 6: 467) this species has since been reported from North Carolina by Coker (Jour. Elisha Mitchell Soc. 43: 233. 1928). So far as I am aware, these are the only previous reports of this interesting and distinctive fungus. The other species of the genus are equally rare. *S. Brefeldianum* Möller is known only from Brazil and *S. magnum* Bodijn has recently been described from Borneo and Java. *S. Cerasi* Bourd. & Galz., reported from France, is to be excluded since Bodijn (Bull. Jard. Buitenzorg III. 13: 268. 1934), after examination of type material, finds that it is not only not a *Sirobasidium*, but that it is perhaps not even a Basidiomycete. In view of the rarity and scattered distribution of the genus, it was of unusual interest to find two collections of *S. sanguineum* in the Australian material, both from Mt. Lofty, South Australia.

In the original publication, Lagerheim and Patouillard describe the fructification as blood red, 4-20 mm. long; the basidia borne in short chains of two to four, separating readily,  $18-20 \times 10-12 \mu$ , and becoming divided into four cells by longitudinal or oblique septa, each division bearing directly, without a "sterigma," an elongated fusoid spore  $17-20 \times 6-8 \mu$ . Coker notes that the color is at first pale, later changing to terra cotta, red or cranberry and gives the size of the fructification as 3-20 mm. broad and 1-5 mm. thick. He describes the basidia as reddish brown, mostly pear-shaped, up to  $22 \mu$  long and mostly  $12-15 \mu$  in diameter, irregularly divided into four cells; the spores as subelliptic, pointed and bent at one end, mostly  $15-23 \times 5.5-7.7 \mu$ , germinating in yeast-like fashion.

Dr. Cleland notes that his No. 40, when collected, consisted of "gelatinous opaque cerebriform masses, pallid to light ochraceous

buff," which is a good description of its appearance when soaked. Of the other collection, No. 41, he says: "gelatinous, somewhat cerebriform . . . whitish, like chewed bread, becoming tinted sometimes with coral or reddish brown,  $\frac{1}{2}$  to  $1\frac{1}{2}$  inches long, raised." This specimen, when soaked, became salmon to salmon buff of Ridgway. It will be noted that the maximum size given is nearly twice that given in the earlier accounts cited. No. 40 is obviously an older fructification than No. 41 and its pallid appearance may well be due to the fact that the color has been washed out, as not infrequently happens in the case of tremellaceous fungi with red or yellow tints.

Coker's excellent description and illustrations leave little to be added. Clamp connections are often very conspicuous at the bases of the basidia. Spores borne on the lower basidia, hence deeply immersed in the gelatinous matrix, are long and narrow,  $22-26 \times 5-7 \mu$ , while those borne at the surface are shorter and broader,  $14-17 \times 7-9 \mu$ . They germinate by repetition. None were observed which were budding. It is not, of course, unlikely that they may bud under some conditions. The rarity of the species justifies the reproduction of camera lucida drawings illustrating the microscopic structures.

#### HETEROTEXTUS FLAVUS Lloyd (FIG. 2: 8-11).

A fine collection, determined by Dr. Cleland, shows well the reflexed habit emphasized by Lloyd and brought out in his photographs (Myc. Notes 7: f. 2231 and 3124). In his original description (l. c. p. 1151. 1922) Lloyd gives the spore size as  $20 \times 8 \mu$  and says merely that the spores are septate in germination. In a later reference (l. c. p. 1340. 1925) he gives the spore dimensions as  $20-24 \times 8-10 \mu$  and says they are 7-septate. In Dr. Cleland's specimen the spores are  $14-17 \times 6.5-7.5 \mu$ . The septa are rather difficult to see under the dry lens, but under oil immersion they are plain. They vary from three to five, mostly five. None were seen more than 5-septate. There is usually one large guttule in each cell but this may be replaced by two or three smaller ones. In addition to the spores, there were numerous elongated or allantoid conidia in the mounts, apparently borne by

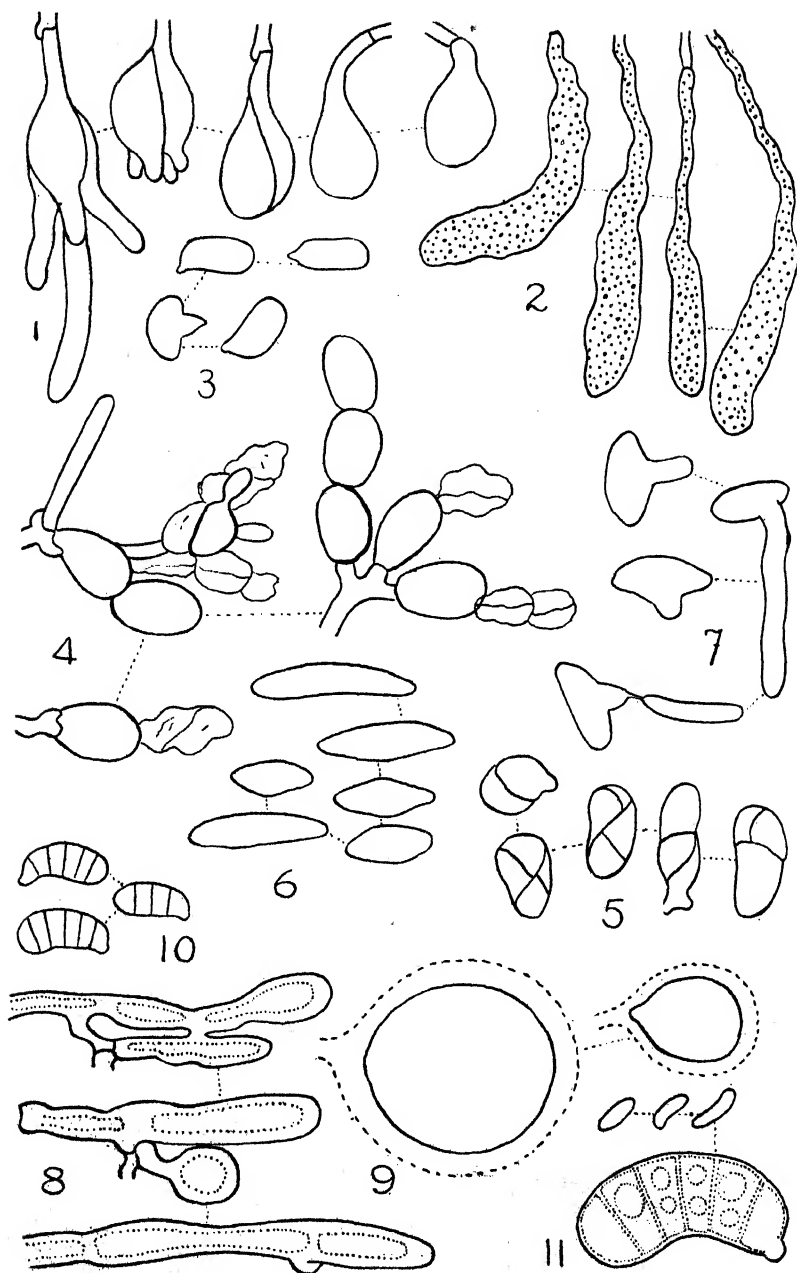


FIG. 2. 1-3, *Seismosarca hydrophora*; 4-7, *Sirobasidium sanguineum*; 8-11, *Heterotextus flavus*.

the spores in germination. The inflated peridial cells are blunter than those of *H. alpinus*; more like those of the congeneric species known as *Guepinia Peczisa* Tul. (*Guepiniopsis Peczisa* Pat.) although much larger (See Mycologia 24; pl. 5. 1932). In certain sections, areas appeared in which what seemed once to have been portions of the peridium had been invaginated. In such areas there were numerous large vesicular cells with gelatinous outer walls (FIG. 2: 9) which may have developed from the peridial cells.

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#### EXPLANATION OF FIGURES

All figures drawn with aid of camera lucida. Fig. 2: 11, drawn at a magnification of  $\times 2436$  and reduced in reproduction approximately to  $\times 1755$ ; all other figures drawn at a magnification of  $\times 1110$  and reproduced at approximately  $\times 800$ .

Fig. 1. *Sebacina megaspora*. 1, young probasidium; 2, nearly mature probasidium; 3, detached basidium with developing epibasidia, hypobasidium still unseptate; 4, detached basidium nearly ready to produce spores; 5, gloeocystidia, one still hyaline, three filled with yellow granules; 6, basidiospores; 7, two basidiospores preparing to germinate by repetition; 8, attached septate basidium, the epibasidia very short; 9, nearly mature and highly vacuolate basidium, still attached, and with a young probasidium at base; 10-11, spores; 12, large spore-like body without apiculus. Fig. 1-7 drawn from Cleland 43 (Type); 8-10 from Cleland 39; 11-12 from Cleland 24.

Fig. 2. *Scismosarca hydrophora*, 1-3. 1, basidia in various stages of development; 2, gloeocystidia; 3, spores, one preparing to germinate by repetition. *Sirobasidium sanguineum*, 4-7. 4, groups of basidia; 5, isolated basidia showing variation in septation; 6, spores, showing variation in size and shape; 7, germinating spores, one certainly, two others probably germinating by repetition. *Heterotextus flavus*, 8-11. 8, peridial cells; note anastomosis in uppermost; 9, large vesiculate bodies with gelatinous walls, from invaginated margin; 10, basidiospores; 11, basidiospore and three conidia,  $\times 1755$ .

# NYCTALIS PARASITICA AND N. ASTEROPHORA IN CULTURE<sup>1</sup>

G. E. THOMPSON<sup>2</sup>

(WITH 21 FIGURES)

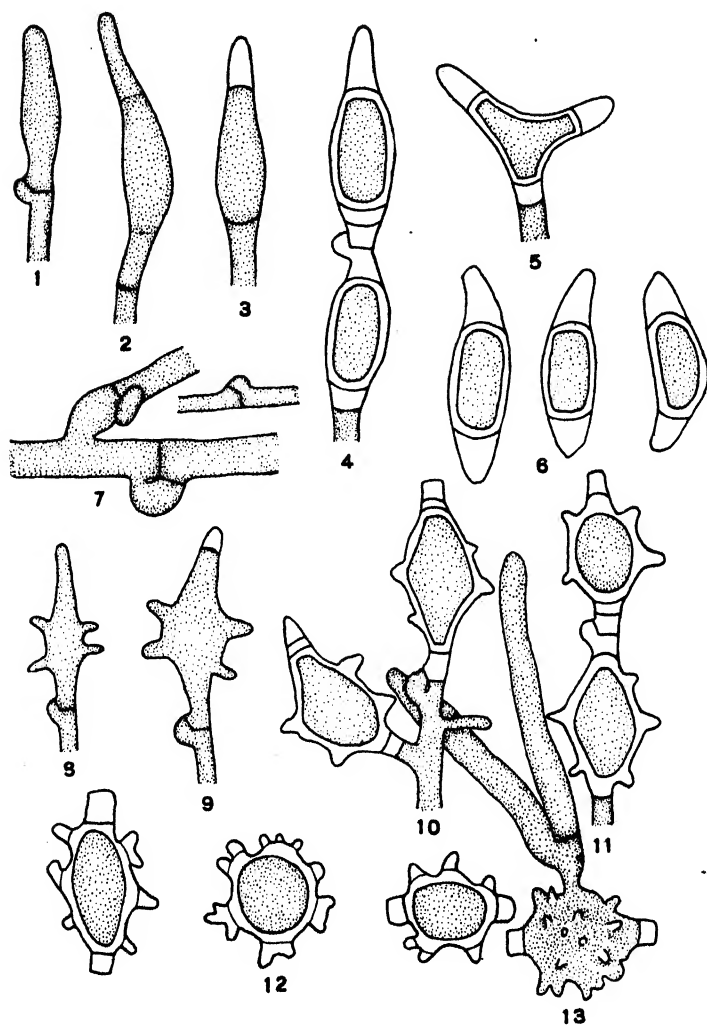
The genus *Nyctalis* in North America contains two species, *Nyctalis parasitica* (Bull.) Fries and *N. asterophora* Fries. The former is especially interesting since its occurrence in North America has been reported on only a few occasions. Overholts (1930, 1933) reports its collection on *Russula* in Jefferson County, Pennsylvania. It had been collected previously by Atkinson in 1917 near Seventh Lake in the Adirondack Mountains, notes and photographs being preserved in his herbarium. In Seymour's Host Index it is listed as occurring on *Russula foetens*. These appear to be the only records of its collection in North America.

The other member of this genus, *N. asterophora*, is a more common species, yet of sufficient rarity to cause unusual interest whenever it is found. It appears to have been collected first in North America by Peck (1872) at Poughkeepsie, New York. Its occurrence in North America has also been reported by Lloyd (1901), Hard (1908), Murrill (1914), Kauffman (1918), Coker (1919), and Overholts (1933). It has been collected no doubt by others throughout the continent. The following genera of the Agaricaceae have been reported as its hosts: *Cantharellus*, *Lactarius*, *Russula*, *Clitocybe*, and *Armillaria*. The literature dealing with the parasitism of these two species of *Nyctalis* and with the earlier culture work of Brefeld is admirably and fully summarized by Buller (1924).

During October, 1933, collections of both species were made by

<sup>1</sup> Presented at the meeting of the Mycological Society of America held at Boston, Massachusetts, December 28-30, 1933.

<sup>2</sup> The writer is indebted to Professor H. M. Fitzpatrick for his valuable criticisms and suggestions in the preparation of this paper, and for his generous assistance in the arrangement of the plates.

FIGS. 1-13. *Nyctalis parasitica* and *N. asterophora* in culture.

the writer near Ithaca, New York, on decomposing fruit bodies of unidentified species of the Agaricaceae, and with little effort both were obtained in pure culture on malt agar in petri dishes. In the isolation of *N. asterophora* chlamydospores were dusted over the surface of the agar. In the case of *N. parasitica* plantings of small fruit bodies were made. From the resulting mycelial



FIGS. 14 and 15. *Nyctalis parasitica* and *N. asterophora* in culture.

growth, transfers were made to test tubes containing the same medium.

Additional media were tried, and it was found that cornmeal, oatmeal, and potato dextrose provide suitable substrata for the growth of *N. parasitica*, while cornmeal and oatmeal are favorable for the growth of *N. asterophora*.

Mature fruit bodies of both species develop within a week, and resemble those found in nature, although there is a tendency for

them to have longer, thinner stalks, and smaller pilei. Chlamydospores wholly like those found in nature are produced in the rudimentary gills of *N. parasitica* and on the surface of the pileus of *N. asterophora*. Chlamydospores similar to those formed in the pilei are also produced quite abundantly on superficial and submerged hyphae. They are borne usually in the tips of the branches, but sometimes occur in chains. In *N. parasitica* the wall is smooth, while in *N. asterophora* it is spiny or warty. Clamp connections appear regularly and clearly.

No attempt was made to induce the germination of the chlamydospores, but in a few cases their germination in *N. asterophora* has been observed.

Although basidiospores have been reported for both species, their production apparently is rare. A careful search of fruit bodies, both those occurring in nature and those produced in culture, failed to reveal any spores of this type. Consequently cultures from this source could not be obtained.

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FIGS. 16-21. *Nyctalis parasitica* and *N. asterophora* in culture.

## EXPLANATION OF FIGURES 1-21

Figures 17-21 photographed by G. F. Atkinson; all others made for the writer by W. R. Fisher.

Fig. 1-3, stages in the development of chlamydospores of *N. parasitica* on malt agar ( $\times 850$ ); 4-6, mature chlamydospores of *N. parasitica* ( $\times 850$ ); 7, clamp connections produced on the mycelium in culture ( $\times 850$ ); 8-11, stages in the development of chlamydospores of *N. asterophora* ( $\times 850$ ); 12, mature chlamydospores of *N. asterophora* ( $\times 850$ ); 13, germinating chlamydospore of *N. asterophora* ( $\times 850$ ); 14, *N. asterophora* (three tubes to left) and *N. parasitica* (three tubes to right) after 20 days growth on (left to right) potato dextrose, malt, and cornmeal agar respectively ( $\times 0.34$ ); 15, *N. parasitica* (left) and *N. asterophora* (right) after 20 days growth on malt agar ( $\times 0.56$ ); 16, *N. asterophora*, after one week's growth on malt agar ( $\times 0.75$ ); 17, *N. asterophora* on *Lactarius* sp.; 18, *N. asterophora* on *Russula nigricans*; 19, *N. asterophora* on undetermined host; 20, *N. parasitica* on *Russula* sp.; 21, *N. parasitica* on *Russula foetens*.

# THE DEVELOPMENT OF THE ASCOCARP OF ACROSPERMUM COMPRESSUM

HELEN BRANDRIFF <sup>1</sup>

(WITH 11 FIGURES)

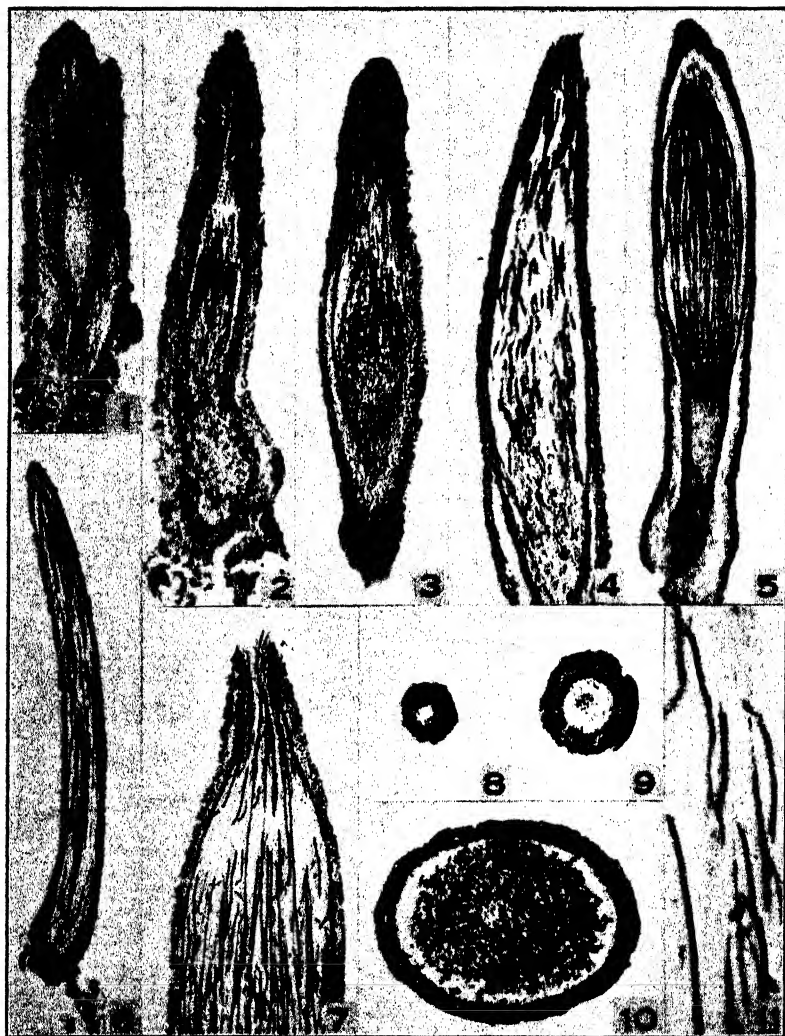
The genus *AcrospERMum* was founded by Tode (1790) with *A. compressum* as the type species. Rehm (1887) considered the genus as one of the Hysteriales. Ellis and Everhart (1892) transferred it from that order to the Hypocreales. The family AcrospERMaceae was erected for the genus by Lindau (1896) who incorporated it tentatively in the Hysteriales. Von Höhnelt (1917), regarding the fungus as undoubtedly pyrenomycetous, placed it in the Sordariaceae of the Sphaeriales. Riddle (1920), who studied the internal structure of the mature ascocarp in stained paraffin sections, concluded that the genus was clearly related to the Hypocreales, it being obviously similar to them in texture and coloration. Clements and Shear (1931) follow Ellis and Everhart and Riddle in considering *AcrospERMum* as one of the Hypocreales. Arnaud (1930) recently added one more taxonomic position for consideration, namely, that of the Caliciées, a discomycetous group treated by him as closely related to the Coryneliales. These several divergent points of view, with the exception of that of Riddle, were based chiefly on the superficial appearance of the fruit-body.

As the taxonomic position of *AcrospERMum* is clearly in doubt, and as its possible relationship to the Coryneliales is of interest in connection with researches in progress on that group, the present investigation was suggested by Professor Fitzpatrick. Emphasis has been placed by us upon the nature and origin of the ascocarp wall and ascigerous cavity, the initiation and development of the asci, and the shape and character of the ostiolar opening.

<sup>1</sup> This investigation has been carried on under the direction of Professor H. M. Fitzpatrick, to whom the writer is deeply indebted.

*AcrospERMUM compressum* Tode has been reported of common occurrence on a number of herbaceous plants in this country and Europe. Collections in the vicinity of Ithaca, New York, have been made on decaying petioles and leaves of *Caltha palustris*, on culms and blades of grass, and on standing wintered stems of an unidentified herb. Additions to this list obtained from the collections in the herbarium of The New York Botanical Garden comprise *Agrostis perennans*, *Arctium* sp., *Cinna arundinacea*, *Elymus canadensis*, *Impatiens fulva*, *Lunaria* sp., *Phytolacca* sp., *Urtica dioica*, *U. gracilis*, *Verbena* sp., and *Vitis* sp. Though a survey of this list would seem to indicate that the fungus may be collected on many plants, and though considerable effort was expended in searching for it, we found it at only one location in the Lloyd Preserve at McLean, near Ithaca, New York, growing on the overwintered petioles and more rarely on the blades of the leaves of *Caltha palustris*, and on the culms and leaves of nearby grass. Collections were made over a period of two months from the middle of April to the middle of June. Young fruit-bodies were found only with difficulty.

CULTURAL EXPERIMENTS.—An attempt was made to grow the fungus in pure culture in order that immature stages, difficult to locate in the field, might be available for use in the developmental study. Cultures were obtained from mature ascospores. Several ascocarps were attached to the lids of agar plates, and falling spores were caught on the surface of the agar below. The germination of the spores was observed and transfers were made from hyphal tips. Intermingling of hyphae from more than one ascospore occurred in some of the cultures. Growth was slow and in all the plates was essentially identical, being in general rather scant and delicate. After three weeks, fruiting structures developed. These had the appearance of spermatogonia or very small pycnidia. They were provided with short beaks, and contained minute unicellular bodies of the aspect of spermatia. These should perhaps be designated as pycnospores, for under suitable conditions they germinated within forty-eight hours, and gave cultures indistinguishable in appearance from those obtained from ascospores. Periodic observations of plants in the field, which had borne ascocarps in the spring, were made throughout the late spring and



FIGS. 1-11. Ascocarp of *Acrospermum compressum*.

summer months up to the first of September in the effort to find an imperfect fruit form in nature, but none was ever seen. The fungus in culture has failed to develop ascocarps, though grown throughout a considerable range of temperature, and on a variety of culture media.

**THE MATURE ASCOCARP.**—Ascocarps occur singly or in small

groups of two to four. They are superficial, a subiculum, if present, being inconspicuous. The color of the young ascocarp is creamy-white, but at maturity varies from honey-yellow to brown or even brownish-black. In texture the ascocarp is fleshy-cartilaginous to coriaceous, drying horny. The mature fruit-body in shape is elongate-clavate to subcylindric, sessile or subsessile, may reach a length of 3 mm., and at complete maturity is usually compressed laterally. Dehiscence takes place by means of a small circular pseudo-ostiolum (FIG. 8), which may appear elliptical in dried specimens.

The asci are filiform,  $300-400\ \mu \times 4-5\ \mu$ , 8 spored, and surrounded by numerous thread-like paraphyses longer than the asci (FIG. 3, 11). The ascospores are filiform, probably non-septate, nearly as long as the ascus, and entirely fill it (FIG. 11). They are freed by deliquescence of the ascus wall and can be seen protruding through the ostiolar opening as fine threads (FIG. 7).

The mature ascocarp in different collections exhibits considerable variation in shape, size, and color. Fruit-bodies growing on the culms of grass appear to be characteristically shorter, more blunt at the tip, and attached to the substratum by a stouter base. They are brownish-black to black from an early stage and show less indication of darkening from the base upward with maturity than in more typical forms. This variation in size and color was probably the basis for recognition of the species *AcrospERMUM graminum* Libert, later reduced to a variety by Rehm. The fact that we have observed the two types on the same plant, one on the culms of grass, the other on its leaves, and in the same vicinity as the typical form on *Calltha palustris* has led us to assume that but one species is involved, i.e., *AcrospERMUM compressum*. Proof of this assumption by inoculation studies was not undertaken.

DEVELOPMENT OF THE ASCOCARP.—At its earliest stage the ascocarp is merely a protruding lobe of homogeneous, pseudoparenchymatous, stromatic tissue. In section it reveals neither cavity nor specialized sexual elements. As it undergoes further development and pushes upward to assume the typical columnar form, the hyphae composing its interior become much elongated in the vertical direction and are narrow and only slightly branching (FIG. 1). These hyphae soon undergo disintegration, and the ascigerous

cavity or locule begins to make its appearance. As the stromatal hyphae disappear the interior of the young ascocarp comes to be filled with ascogenous hyphae (FIG. 2) and later with paraphyses and asci (FIG. 3, 4). From the preparations obtained it is impossible to determine the exact point of origin of the ascogenous hyphae or to distinguish clearly between ascogenous hyphae and young asci except by their positions relative to the developing activity. The paraphyses form more rapidly and are the first to reach the tip of the fruit-body, the young asci in turn pushing up through them (FIG. 3). Bordering the cavity in some preparations a deeper staining layer of hyphae gives somewhat the aspect of a perithecial wall lying within less deeply staining stromatic tissue (FIG. 3-5). The fact that this apparent wall is diffused and loses its identity at the base of the fruit-body (FIG. 3) and is absent in the early stages of cavity formation (FIG. 1, 2), indicates that it is not a true perithecial wall. Moreover, in some cases it is present on one side of the ascigerous cavity (FIG. 3) while wholly absent on the other. These facts lead us to conclude that this apparent wall is in fact merely a zone of stromatal tissue which is more compact and deeply staining than surrounding tissue. In general there can be said to be a loose layer of tissue (FIG. 10) lying between this zone and the firmer peripheral layer constituting the outer surface of the ascocarp. According to the point of view of Miller (1928) who has contributed to a clearer understanding of the development of the wall of the Pyrenomycetes, the true perithecial wall originates directly from the coiled archicarp. In our preparations an archicarp was not observed at any stage, and such a true perithecial wall is certainly absent.

The mature ascocarp in longitudinal section usually shows a conspicuous basal region of homogeneous tissue lying beneath the ascigerous locule (FIG. 5). In some ascocarps this is relatively limited in extent (FIG. 6). In no case does it reach the height of development attributed to it by Arnaud, who places *Acrospermum* in the Caliciées and describes the fruit-body as a stipitate apothecium. He separates the Caliciées from the Coryneliées largely on the shape of the fruit-body, stating that in the former it is that of a shallow cup, while in the latter it is that of a deep urn. His

inclusion of *AcrospERMum* in the Caliciées on this basis seems indefensible.

The asci cannot be said to form a definite palisade layer such as is typical of the discomycetous fungi. They arise over a relatively limited area at the bottom of the locule and in the aggregate constitute a fascicle in which the long sinuous asci converge toward the apical opening.

Dehiscence of the ascocarp occurs by means of a definite circular pore (FIG. 7, 8). In the case of collapsed, dried specimens, which have a distinctly compressed aspect, the pore appears elliptical. Cases of this sort probably account for the opinion of certain authors that the opening is of the nature of a longitudinal slit, thus showing a relationship with the Hysteriales.

Though the apical opening of the ascocarp is a definite pore, it is not the periphysis-bordered ostium of the true sphaeriaceous fungi. It is more of the nature of the pseudo-ostium formed in dothidiaceous genera.

CONCLUSIONS.—There seems to be no point at which this fungus shows a close relationship to the Hysteriales. The fructification is erect and columnar while those of the Hysteriales are characteristically horizontal and linear. Moreover, in texture it is typically fleshy-cartilaginous when moist and horny when dry, and is usually light-colored when young becoming darker with age, not black and carbonaceous at all stages. Apparently the authors who placed *AcrospERMum* among the Hysteriales did so mainly on the basis of their interpretation of the dehiscence as a longitudinal slit. Typical dehiscence in the order Hysteriales occurs along a dorsal suture, a long slit being formed which opens wide enough to expose the ascospores, and results in a condition approaching that of the Pezizales. The pore of *AcrospERMum* can hardly be interpreted as similar. The additional point that the asci and paraphyses of *AcrospERMum* constitute a fascicle of elements converging toward the ostiole and not forming a definite hymenial layer leaves no reason for placing *AcrospERMum* in the Hysteriales.

Criticism of its inclusion in the Hypocreales rests on our interpretation of the fruit-body as a unilocular dothidiaceous stroma. The ascocarp is strikingly similar to that of many species of the Hypocreales in respect to texture and color and in the filiform



character of the spores. The convergence of asci and paraphyses toward the tip of the ascocarp and its dehiscence by a definite apical pore are admittedly pyrenomycetous characters. The sterile tissue at the base of the fruit-body, while typically discomycetous, is also present in some Pyrenomycetes. The decisive point involved is the absence of a true perithecial wall.

Among the dothidiaceous fungi, the Pseudosphaeriales and Coryneliales would seem to approach *Acrospermum* most closely. The columnar shape of its ascocarp affords at least a superficial resemblance to members of the latter order. Dehiscence among the Coryneliales is varied. Fitzpatrick, who treated the order taxonomically, describes the locule as opening wide at maturity exposing the asci. Dehiscence in some species occurs along a suture or line. In others, several radial clefts give the apex of the ascocarp a lobed appearance. In some, as in *Caliciopsis*, a pseudo-ostium of variable diameter is formed as in the Pseudosphaeriales. In its superficial habit *Acrospermum* differs from the Coryneliales, the fruit-bodies there being characteristically clustered on an erumpent cushion of stromatic tissue.

Finally, though a definite statement as to the placement of this fungus which has puzzled mycologists for over a century cannot be made, it would seem that the dothidiaceous nature of the species has been demonstrated, and that a relationship to the Coryneliales and Pseudosphaeriales is indicated. Temporarily it may be assigned to a position in the vicinity of these two orders.

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## EXPLANATION OF PLATE

Photographs by W. R. Fisher. Fig. 1, columnar stromatic lobe, in longitudinal section, showing early stage of disintegration of hyphae of interior to form the ascigerous locule,  $\times 210$ ; 2, the partially defined locule in longitudinal section showing developing ascogenous hyphae,  $\times 210$ ; 3, young asci growing up through paraphyses, locule showing apparent perithecial wall on one side only,  $\times 180$ ; 4, nearly mature asci converging toward apex of locule,  $\times 180$ ; 5, mature ascocarp in longitudinal section showing deeper staining zone of tissue bordering the locule,  $\times 180$ ; 6, mature ascocarp in longitudinal section showing an unusually long locule and relatively little basal tissue,  $\times 85$ ; 7, longitudinal section of apical portion of ascocarp showing asci and ascospores protruding through pseudo-ostium,  $\times 210$ ; 8, transverse section of apical region of ascocarp showing the circular pseudo-ostium,  $\times 210$ ; 9, transverse section of subapical region lying a few microns lower than that pictured in preceding figure,  $\times 210$ ; 10, transverse section of median region of same ascocarp as that shown in preceding two figures,  $\times 210$ ; 11, longitudinal section of mature ascocarp, showing paraphyses and asci, the latter containing mature ascospores,  $\times 340$ .

# THE GENUS UNDERWOODIA

HELENE A. NUSSLÉ

(WITH 1 FIGURE)

The genus *Underwoodia*, consisting of the single species *Underwoodia columnaris* Peck, was founded by Peck (1890) on three specimens collected at Kirkville, Onondaga County, New York, in 1889. He dedicated the genus to Professor L. M. Underwood who had called the plants to his attention. The fungus is of exceptional interest on account of its peculiar form and structure. As it is generally regarded as one of the rarest of North American Discomycetes, the recent collection of a specimen at Ithaca, New York, aroused considerable local interest and stimulated the survey of the literature resulting in this paper.<sup>1</sup> The fungus had been collected at Ithaca only once before, thirty-three years earlier, by a strange coincidence on the same day of the month of July.

Fifteen collections of the species are mentioned in the literature. Five others, announced here for the first time, bring the total to twenty. Eight of these were made in New York, six in Michigan, one in Illinois, one in Iowa, and four in Manitoba. Data concerning these collections are assembled in as complete form as possible in the accompanying table. These show that the fungus has been reported from only seven rather widely separated localities during a period of forty-six years. It is possible of course that additional collections have been made of which we have encountered no record. Underwood searched the type locality in six successive years following the original discovery of the fungus, but found there only three additional specimens (1899).

The species has been collected as early as May and as late as September. Official figures on rainfall for the years in which the fungus has been observed, would seem to indicate a correlation with periods of excessive precipitation. Double fruit bodies have

<sup>1</sup> The writer wishes to acknowledge her indebtedness to Professor H. M. Fitzpatrick, who suggested the publication of this paper and supervised its preparation.

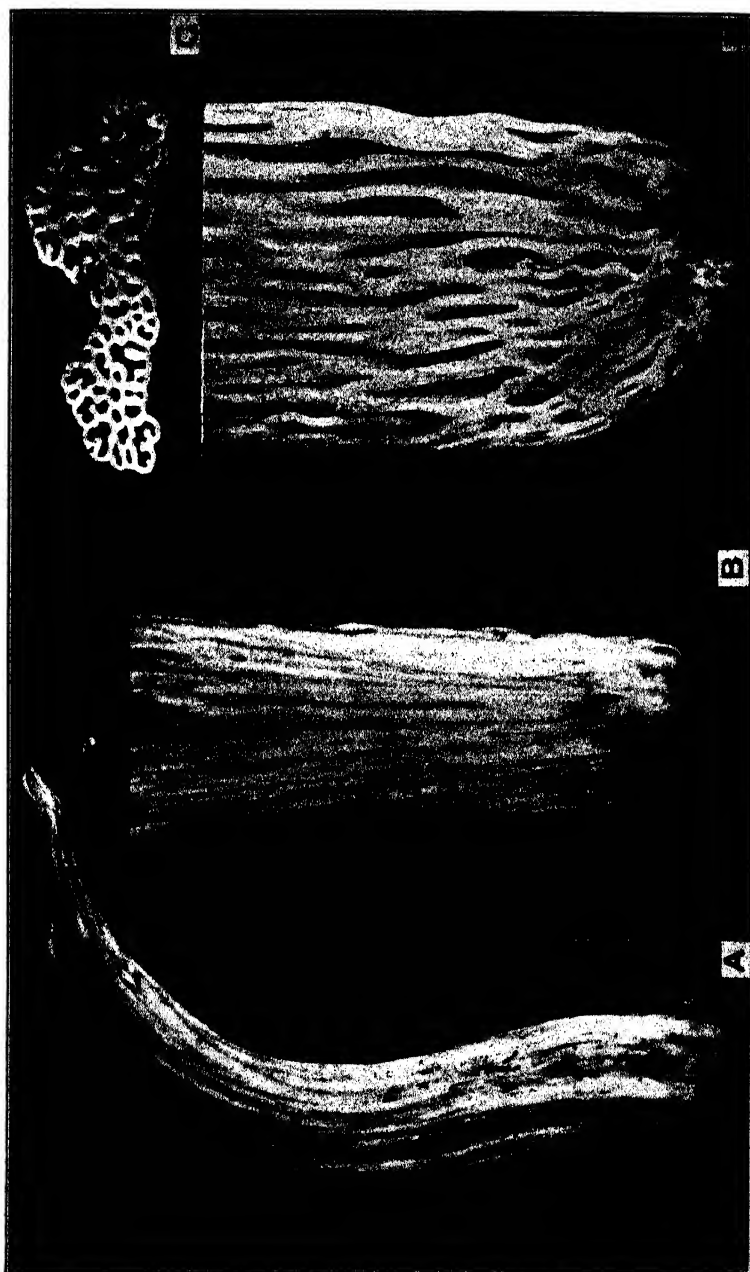


FIG. 1. *Underwoodia columnaris*.

Col- lec- tion	Collector	Place	Number of Individuals	Present Location of Specimens	Date of Collection	Place of Publication
1	J. T. Fischer	Kirkville, N. Y.	3	N. Y. State Museum, Albany N. Y. Bot. Garden	July, 1889	N. Y. State Museum Rept. 43: 78, <i>pl.</i> 4. 1890.
2	L. M. Underwood	"	1	" " "	June, 1890	Mycologia 10: 1-3, <i>pl.</i> 1. 1918.
3	" "	"	1	" " "	June, 1893	
4	E. T. Harper	Neebish Is., Mich.	"cluster"	Field Museum, Chicago	August, 1897	Torrey Bot. Club Bull. 45: 77-86, <i>pl.</i> 1-3. 1918.
5	" "	Mackinac Is., Mich.		" " "	Summer, 1898	
6	" "	Neebish Is., Mich.		" " "	September, 1898	
7	" "	" " "		" " "	September, 1898	
8	" "	" " "		" " "	September, 1898	
9	C. O. Smith	Ithaca, N. Y.	1	Cornell Univ.	July 10, 1902	Present paper.
10	E. T. Harper	Neebish Is., Mich.	1	Field Museum, Chicago	Summer, 1907	Torrey Bot. Club Bull. 45: 77-86, <i>pl.</i> 1-3. 1918.
11	" "	Bureau Junction, Ill.	2	" " "	May, 1908	

Col- lec- tion	Collector	Place	Number of Individuals	Present Location of Specimens	Date of Collection	Place of Publication
12	S. H. Burnham	Tripoli, N. Y.	1	N. Y. Bot. Garden	July 15, 1917	Mycologia 10: 1-3, pl. I. 1918.
13	"	"	1	" " "	July 22, 1917	
14	"	"	1	Cornell Univ.	July 20, 1919	Present paper.
15	G. R. Bisby	Winnipeg, Man.	2	Manitoba Agr. College	July 13, 1927	
16	"	"	3	" " "	July 28, 1928	Bisby, Buller, and Dearness, Fungi of Manitoba, pp. 30, 58. 1929.
17	"	"	"several"	" " "	August 1, 1928	
18	"	"	"	" " "	July 10-11, 1933	
19	G. W. Martin and H. C. Gilbert	Estherville, Iowa	"	Univ. of Iowa	July, 1933	Present paper.
20	Chas. A. Taylor	Ithaca, N. Y.	1	Cornell Univ.	July 10, 1935	Present paper.

been found more often than would have been expected. Such individuals have been figured by Seaver (1918: 1928), and Harper (1918), and the recently collected Ithaca specimen is of that type (FIG. A). Harper, in his description of the fungus (1918) gives the length of the fruit body as ranging from 5 to 35 cm. The specimen collected at Tripoli, N. Y., in 1919 and reported here for the first time must have exceeded this maximum figure appreciably, since in its present dry state it measures 36 cm.

The Ithaca specimen measured 6 cm. in diameter and 30 cm. in length. It was light buff in color and emitted a strong and characteristic odor. In the grooved appearance of its surface (FIG. B), the chambered aspect of its interior (FIG. C, D), and the size and shape of its spores it agrees with descriptions of previously collected individuals. Attempts to induce spore germination, as well as efforts to get the fungus in pure culture from tissue plantings have been unsuccessful.

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#### EXPLANATION OF FIGURE

*Underwoodia columnaris* Peck. Fig. 1. A, double fruit body characteristically curved and tapering; B, surface of basal portion of fruit body showing characteristic grooved appearance; C, transverse section of fruit body cut midway between base and apex; D, longitudinal median section of base of fruit body showing tubular chambers.

# A NEW SPECIES OF STYLOPAGE PREYING ON NEMATODES

CHARLES DRECHSLER

(WITH 1 FIGURE)

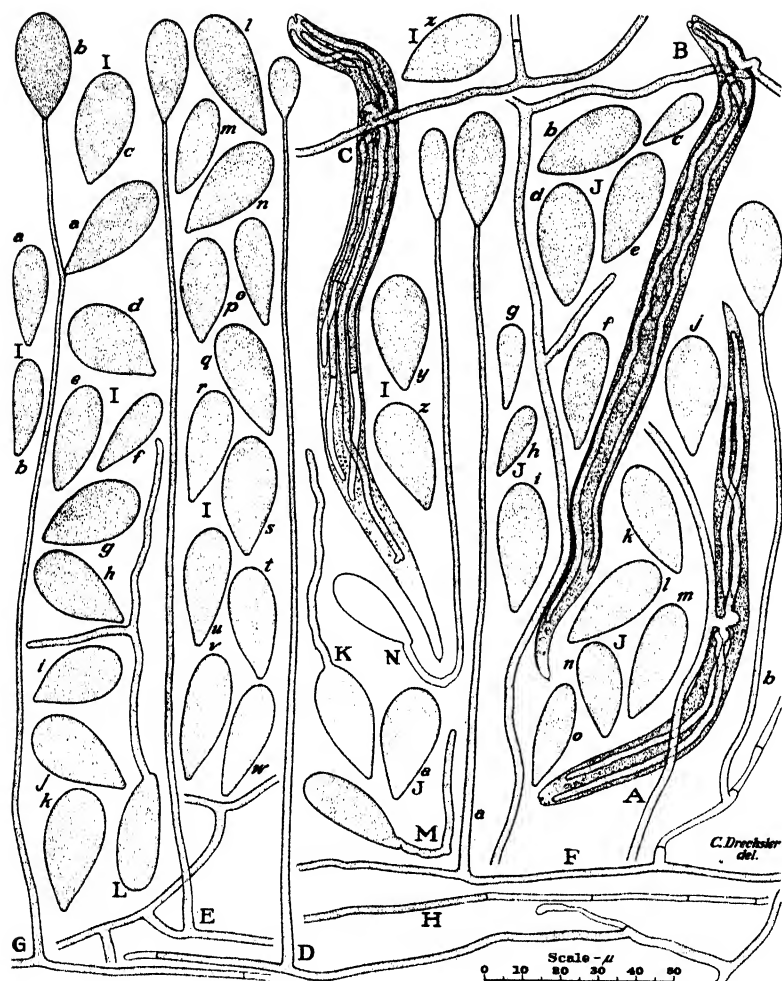
In Zopf's (11) account of the capture of nematodes by *Arthrobotrys oligospora* Fres. and *Monosporidium repens* Zopf were described, apparently for the first time, instances of a biological habit comparable in part to the carnivorous habit of insectivorous flowering plants. More recently (1, 2, 3) nearly a score of additional fungi occurring in soil, in leaf mold, and in solid decaying materials generally, have been found to capture and consume nematodes in large numbers; evidently, indeed, subsisting in nature entirely through such predacious activity. By far most of these fungi are closely related to those dealt with by Zopf, being referable to a group of interrelated genera including *Arthrobotrys*, *Trichothecium*, *Cephalothecium*, *Dactylaria*, *Dactylella* and *Monacrosporium* (4). The relatively few nematode-capturing forms alien to this hyphomycetous series are conidial phycomycetes belonging to the Zoopagaceae, a family whose known members are mostly destructive to terricolous amoebae, some operating in parasitic, others in predacious relationships (5, 6). Of the few species preying on nematodes, only one, *Stylopaga hadra* Drechsl., has hitherto been described in detail (7); so that the description offered herein, of a second species of like biological habit, may be of interest even in the absence of pronounced departures in morphology.

The fungus in question was obtained in quantity from several samples of soil collected by F. L. Wellman in celery fields near Sanford, Florida, January 1935. Pinches of the soil were placed on old maize-meal-agar plate cultures liberally infested with nematodes representing species of *Rhabditis*, *Cephalobus* and *Acrobeles*. After a period varying usually from 1 to 3 weeks, vegetative mycelium was found present here and there in fairly extensive tracts. In general character this mycelium resembled that of *Stylopaga*



*hadra*; the hyphae, filled with densely granular protoplasm, following rather straightforward courses to give off branches at moderate or longish intervals, mostly at wide angles. Evacuation of the older filaments was found frequent, the retreat of the protoplasm being accomplished in stages and thus resulting, as in many other phycomycetes, in the laying down of a succession of cross-walls (FIG. 1, *H*). As the hyphae were consistently narrower than those of *S. hadra*, scarcely measuring two-thirds as much in width, the mycelium had a noticeably more graceful, less staring appearance.

Capture of nematodes was brought about by adhesion to living mycelial filaments provided with deposits of a yellowish sticky substance (FIG. 1, *A-C*). Commensurate with the smaller width of hyphae in the present species, the animals caught and held on them were, on the whole, smaller than those destroyed by *Stylopage hadra*; the eelworms captured measuring ordinarily less than .2 mm., and rarely more than .25 mm. in length. Globose protuberances like those formed on filaments of *S. hadra*, presumably serving to increase the areas of adhesive contact, have never been observed here; their absence probably accounting in part for an apparent incapacity to hold larger and more vigorous prey. As far as could be determined the death of a captured animal was never hastened through any special development such as is represented among the predacious Hyphomycetes in the intrusion of a bulbous outgrowth, or in the closing of a constricting loop. Consequently the struggles of the hapless eelworm to free itself were continued for a relatively long period. When the ineffectual writhing had become feeble through exhaustion, the integument of the animal was perforated and hyphae thrust inside, where the progress of their elongation was promptly marked by readily visible degeneration of organs and musculature. Death appeared to ensue about at the time the internal hyphae had extended themselves nearly the entire length of the nematode. These internal hyphae were approximately of the same width as the generality of external hyphae. On depletion of the fleshy substance of the prey, the protoplasmic contents were gradually withdrawn back into the parent filament. Thus in the end, only the empty collapsed integument adhering to a local irregularity in the filament remained behind as visible evidence of the animal's fate.

FIG. 1. *Stylopage leiohypha*.

The scattered conidiophores of the Florida fungus (FIG. 1, D; E; F, a, b; G) closely resemble those of *Stylopage hadra* in manner of origin and in general habit; but differ from them in having smaller dimensions. Owing to the rather wide variation in height of the fertile hyphae, the difference in stature between the two species is not especially striking; but the difference in width of the conidiophores, which is more constant as well as proportionally more pronounced, readily distinguishes the slenderer from the

sturdier form. As might be expected, the narrower conidiophores produce the smaller conidia (FIG. 1, *I*, *a-z*; *J*, *a-o*); measurements of 50 spores of the Florida fungus selected at random giving computed averages of  $29.3\ \mu$  and  $12.8\ \mu$  for length and width respectively, as compared with averages for the corresponding dimensions in *S. hadra* of  $34.6\ \mu$  and  $17.3\ \mu$  respectively. In size, therefore, the southern form is intermediate between *S. hadra* and *S. araca* Drechsl. Its resemblance to the latter species, with respect to a feature shared, to be sure, by all the rest of its amoeba-capturing congeners (6), may perhaps appropriately be suggested in a term having reference to the absence of globose protuberances in the capture of prey.

### ***Stylopage leiohypha* sp. nov.**

Sparsa; hyphis sterilibus incoloratis,  $2-3\ \mu$  crassis, sine tuberibus animalia tenentibus, integumentum perforantibus, hyphas  $2-2.5\ \mu$  crassas intus evolvitibus, carnem exhaurientibus. Hyphae fertiles  $125-300\ \mu$ , basi  $2.5-3.5\ \mu$  crassae, sursum attenuatae, apice  $1-1.4\ \mu$  crassae, unicum conidium vel interdum usque 3-4 conidia post incrementa repetita ferentes; conidiis incoloratis, obovoideis vel elongato-obovoideis,  $20-35\ \mu$  longis,  $7-18\ \mu$  latis. Zygosporae ignotae.

Habitat in terra, nematoda diversa usque .25 mm. longa capiens et consumens, prope Sanford, Florida.

Sparse; vegetative hyphae colorless, 2 to  $3\ \mu$  wide, capturing nematodes without the production of orbicular protuberances, perforating the integument of each animal, then giving rise inside to haustorial hyphae, 2 to  $2.5\ \mu$  wide, which assimilate the fleshy contents. Conidiophores 125 to  $300\ \mu$  high,  $2.5$  to  $3.5\ \mu$  wide at the base, tapering upward, 1 to  $1.4\ \mu$  wide at the tip, bearing a single conidium, or often producing up to 3 or 4 conidia one by one after repeated elongation. Conidia colorless, obovoid or elongate obovoid, measuring 20 to  $35\ \mu$  (average  $29.3\ \mu$ ) in length by 7 to  $18\ \mu$  (average  $12.8\ \mu$ ) in width. Zygospores unknown.

Occurring in soil, capturing and consuming nematodes up to .25 mm. in length belonging to species of *Rhabditis*, *Cephalobus* and *Acrobeles*, near Sanford, Florida.

The new species contributes little additional information concerning the taxonomic position of the Zoopagaceae. Its conidia germinate usually by a single hypha (FIG. 1, *K*, *L*), which may originate either from the rounded apex, or from a position immediately adjacent to the slightly flattened basal hilum. Often

the germ tube after growing some distance horizontally on the substratum, changes its direction (FIG. 1, *M*) and continues growth vertically into the air as a conidiophore to produce terminally a secondary conidium (FIG. 1, *N*). Apparently the same process may be repeated to give rise to a tertiary conidium. This repetition of development, as was pointed out in the discussion (7) of *Stylophage hadra*, recalls the behavior frequent with conidia of various species of *Empusa*, and thus provides one of the few indications of relationship to the Entomophthorales. These indications direct attention also to the possibility of relationship with other conidial zygomycetes made known in recent years; such, for example, as the Harpellaceae, a family of singular fungi that Léger and Duboscq (8) and Léger and Gauthier (9, 10) have briefly described from the digestive tube and rectal cuticle in the aquatic larvae of various insects. The presence of curious evanescent spiral basal appendages on the conidia of the Harpellaceae, and the biconic shape of the zygosporangium in the forms wherein the sexual stage has been observed, constitute morphological features no less alien to the Zoopagaceae than to the older established groups in the Entomophthorales. Nevertheless, provoking analogies would seem present, which, if supplemented through the discovery of additional types, may well lead not only to an appropriate orientation of the newer groups, but also to a more satisfactory ordering of the old.

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#### EXPLANATION OF FIGURE

Fig. 1. *Stylopage leiohypha*; drawn with aid of camera lucida at a uniform magnification;  $\times 500$  throughout. A–C, Portions of hypha on each of which has been captured a nematode (referable probably to *Cephalobus* sp.), showing haustorial filaments, disorganization of animal's fleshy parts, and in C, early stage in evacuation of haustorial filaments. D, Conidiophore with young growing conidium. E; F, a, b; Conidiophores, each with one fully grown conidium. G, Conidiophore with 2 conidia, a and b, produced successively. H, portion of vegetative hypha, partly evacuated, showing 3 septa in empty portion. I, a-s; J, a-o; Mature conidia. K, L, Conidia germinating vegetatively. M, Conidium with a germ tube developing distally into an erect conidiophore. N, Conidium with a germ tube that has developed distally into an erect conidiophore bearing a nearly mature secondary conidium.

## SOME ASCOMYCETES NEW TO CALIFORNIA

EDITH K. CASII

(WITH 5 FIGURES)

Among recent collections of fungi from Humboldt County, California, made by Mr. H. E. Parks, several seem to be new to that region. Five of these are discomycetes which are apparently undescribed and therefore named as new species, while the sixth is a *Nectriella* not previously reported from North America. Specimens are deposited in the Parks herbarium and in the Mycological Collections of the Bureau of Plant Industry.

### 1. *Arachnopeziza Arctostaphyli* n. sp. (FIG. 1).

Apothecia sessile on sparse subicle of hyaline mycelium, at first subglobose, becoming patellate, cream-color<sup>1</sup> to light buff when dry, .4-.7 mm. diam., attached at the margin by delicate, hyaline hairs; asci clavate, often arcuate, narrowed abruptly at the apex, attenuated toward the base,  $100-115 \times 10-12 \mu$ ; spores irregularly fasciculate, many-guttulate, straight or curved, 7-septate,  $65-80 \times 2.5-3 \mu$ ; paraphyses filiform, branched about half-way from the base, non-septate, granular, hyaline; exciple prosenchymatic, hyaline, with septate hairs at the margin,  $100-120 \times 4-6 \mu$ , occasionally bearing crystals up to  $13 \mu$  in diam.

Apotheciis in mycelio tenui hyalino sessilibus, subglobois demum patellatis, cremeis vel pallidis, .4-.7 mm. diam.; ascis clavatis, saepe arcuatis,  $100-115 \times 10-13 \mu$ , apice acute attenuatis; sporis irregulariter fasciculatis, multi-guttulatis, 7-septatis, rectis curvulisve,  $65-80 \times 2.5-3 \mu$ ; paraphysibus filiformibus, ramosis, granulosis, hyalinis; margine setis hyalinis, septatis,  $100-120 \mu$  longis,  $4-6 \mu$  latis, ornata.

On decorticated stems of *Arctostaphylos Tracyi*, Spruce Cove, Trinidad, Calif., H. E. Parks 5329, Feb. 16, 1935.

Among species with approximately the same dimensions, *Beloniidium pulvinatum* Boud. is gray to purplish, with clavate para-

<sup>1</sup> Color terminology follows that in Ridgway, Color Standards and Color Nomenclature, Washington, 1912.

physes and fifteen-septate spores. *Erinella byssacea* P. Henn. & Nym. from Java seems nearest to the California material. No specimen of this is available for comparison, but it is described as having yellow apothecia and hairs, and paraphyses  $3\mu$  in diameter. *Erinella borealis* Povah, a fungus apparently similar in macroscopic appearance, differs in smaller asci and spores. The filiform paraphyses would prevent this species from falling in the genus *Erinella* and the presence of a thin but widespread and distinct subicle make it a better *Arachnopeziza*.

## 2. *Belonidium Parksii* n. sp. (FIG. 2).

Apothecia gregarious, cupulate, sessile, exterior fuscous, furfuraceous, hymenium glaucous-green, drying chromium-green, margin inrolled and plicate, hysteroïd, triangular, or irregularly folded; asci clavate-cylindrical, abruptly narrowed at the apex, gradually attenuated toward a short stipe,  $65-80 \times 6-8\mu$ ; spores fusoid, straight or slightly curved, obliquely uniseriate below to biseriate above, 4-guttulate, becoming 1-3-septate, acute at both ends,  $11-17 \times 2-4\mu$ , usually about  $13 \times 3\mu$ ; paraphyses filamentous, septate, unbranched, tips granular and slightly enlarged to  $1.5-2\mu$  in diam.; exciple dark-pseudoparenchymatous, cells  $7-12\mu$  in diam., elongated toward the margin, readily breaking up and giving the exterior of the apothecium its furfuraceous appearance.

Apotheciis gregariis, cupulatis, sessilibus, fusco-furfuraceis, hymenio glauco-virido, siccis margine involuto irregulariter plicatis; ascis clavato-cylindraceutis, apice attenuatis, breviter stipitatis,  $65-80 \times 6-8\mu$ ; sporis fusoides, 1-2-seriatis, 1-3-septatis,  $11-17 \times 2-4\mu$ ; paraphysibus filamentosis, septatis, apice  $1.5-2\mu$  diam.; textura excipuli parenchymatica, e cellulis brunneis,  $7-12\mu$  diam., marginem versus elongatis, composita.

On decorticated stems of *Vaccinium parvifolium*, Prairie Creek, Humboldt Co., Calif., Mar., 1935, H. E. Parks 5485 (*Type*), 5335, on *Rhamnus Purshiana*, Feb., 1935, Spruce Cove, Calif.; 5387, on *Garrya elliptica*, 5413, on *Physocarpus capitatus*, 5450, 5455, on *Castanopsis chrysophylla*, Spruce Cove, March, 1935.

## 3. *Scleroderris lobata* n. sp. (FIG. 3).

Apothecia coriaceous, subglobose to cupulate, rarely expanded, breaking through the bark singly or in groups of 2-4, opening by splitting at the margin into 4-6 lobes which fold over one another

on drying, up to 1 mm. in diam. and height, externally blackish brown, smooth, drying glossy black, hymenium light olive-gray; asci cylindrical, short stipitate, gradually narrowed toward the base, rounded and slightly narrowed with thickened wall at the apex,  $90-115 \times 7-9 \mu$ ; spores obliquely 1-seriate below, 2-seriate above, clavate, occasionally 2-, but usually 3-septate, the lower end acute,  $18-20 \times 3-4 \mu$ ; paraphyses numerous, filiform, rarely septate, simple or branched near the tip, slightly and abruptly inflated; subhymenial layer ochraceous-tawny to amber-brown, composed of angular cells  $5-10 \mu$  in diam., outer layer of elongate hyphae forming a thick-walled prosenchyma.

Apotheciis subglobosis cupulatisve, nigro-brunneis, 1 mm. diam. et altis, glabris, margine lobato, hymenio griscoalbo; ascis cylindraceutis,  $90-115 \times 7-9 \mu$ ; sporis 1-2-seriatis, 2-3-septatis, clavatis,  $18-20 \times 3-4 \mu$ ; paraphysibus filiformibus, simplicibus vel furcatis, leniter inflatis.

On twigs of *Ribes Menziesii*, Spruce Cove, Trinidad, Calif., March, 1935, H. E. Parks 5472.

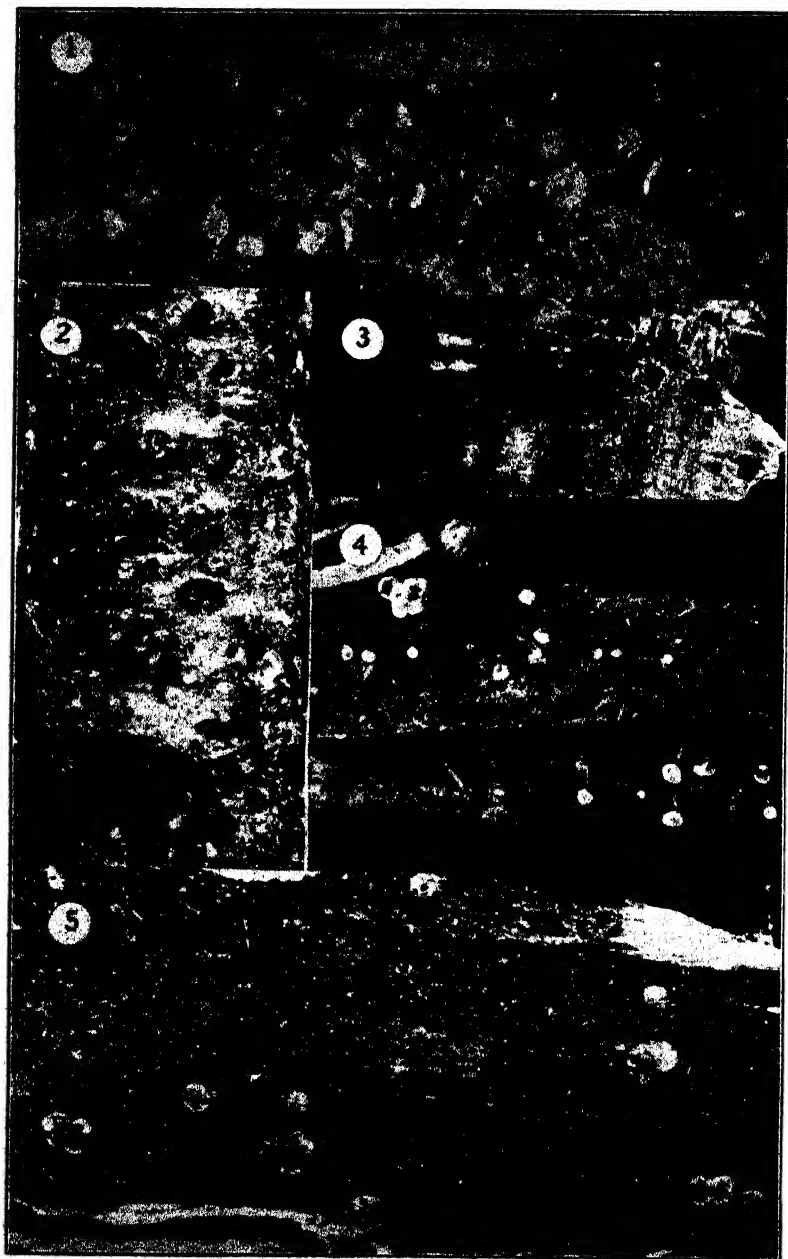
This fungus can be distinguished from *Sclerodermis ribesia* (P.) Karst. by the smooth exciple, lobate margin, and shorter spores; the wide overlapping lobes of the margin were not seen in any similar species on *Ribes*. *Sclerodermis tumoricola* Cash found on *Ribes montigenum* in Colorado differs in the furfuraceous exciple, smaller spores, and its habit of growth on canker-like areas of the host.

#### 4. *Helotium cremeum* n. sp. (FIG. 4).

Apothecia firm, waxy, sessile, patellate, occasionally lobate, .5-1 mm. diam., exterior cream white, hymenium cream-color to cream-buff, margin distinct, whitish furfuraceous; asci clavate, long-stipitate,  $75-90 \times 10-12 \mu$ , narrowed but round at the apex, gradually attenuated toward the base; spores fusoid-clavate, 2-celled, slightly constricted at the septum,  $12-15 \times 4-5 \mu$ , granular, 1-2-seriate, upper cell slightly wider than the lower, containing many small guttulae; paraphyses filiform, septate, unbranched,  $2 \mu$  at the apex; exciple subhyaline, prosenchymatous.

Apotheciis ceraceis, sessilibus, patellatis, cremeis, .5-1 mm. diam., pallide marginatis; ascis clavatis, longe stipitatis,  $75-90 \times 10-12 \mu$ ; sporis fusoid-clavatis, guttullatis, 1-2-seriatis, 1-septatis, leniter constrictis,  $12-15 \times 4-5 \mu$ ; paraphysibus filamentosis, apice  $2 \mu$ ; textura excipuli subhyalina, prosenchymatica.





FIGS. 1, *Arachnopeziza Arctostaphyli*; 2, *Belonidium Parksi*; 3, *Scleroderris lobata*; 4, *Helotium cremeum*; 5, *Helotium nitens*.

On stipes of *Pteridium aquilinum pubescens*, Spruce Cove, Trinidad, Calif., H. E. Parks 4149 (*type*) Mar., 1933, and 5514, April, 1935.

This *Helotium* differs from the species of Helotiaceae reported on ferns (*Pezizella aspidiicola* (Berk. & Br.) Rehm, *P. chryso-stigma* (Fries) Sacc., *P. versicolor* (Desm.) Rehm, *Helotium aureolum* Sacc.) in larger asci and broader spores. It seems most closely related to *Helotium separabile* Karst., in which the spores are narrower and the asci smaller, and to *H. Humuli* (Lasch) De Not., a darker colored fungus with longer spores.

##### 5. *Helotium nitens* n. sp. (FIG. 5).

Apothecia fleshy to subgelatinous, sessile, pulvinate, convex, not distinctly margined, gregarious, sometimes confluent, 1–1.5 mm. diam., 1 mm. high, pale yellow-orange to light salmon-orange, hymenium glistening, even, smooth, drying Mars-orange, exterior slightly paler; asci clavate-cylindrical, rounded and with the wall thickened at the apex to  $5\mu$ , gradually attenuated below to a long stipe,  $150-170 \times 7-8\mu$ ; spores ellipsoid-clavate, at first unicellular, later 1-septate,  $13-18 \times 4-4.5\mu$ ; paraphyses filiform, non-septate, thickly branched near the apex,  $1\mu$  diam., not enlarged; exciple of densely interwoven fine, greenish-yellow hyphae,

Apotheciis carneis, gelatinosis, sessilibus, pulvinatis, 1–1.5 mm. diam., flavo-aurantiis, nitentibus; ascis clavato-cylindraceutis, apice rotundatis, deorsum attenuatis,  $150-170 \times 7-8\mu$  sporis ellipsoideis clavatisve, primum simplicibus, demum uniseptatis,  $13-18 \times 4-4.5\mu$ ; paraphysibus filiformibus, apice dense ramosis,  $1\mu$  diam.

On wood of *Arctostaphylos Tracyi*, Spruce Cove, Trinidad, Calif., Feb. 16, 1935, H. E. Parks 5330.

The asci in *H. nitens* are longer and more slender than in *Helotium subtrabinellum* Bres. and the paraphyses are not swollen at the apex as in that species. The glistening hymenium and subgelatinous character are suggestive of *Calloria*, from which, however, the fungus differs in the prosenchymatic exciple and more fleshy consistency.

6. *NECTRIELLA SAMBUCI* (v. Höhn.) Weese.

Collections determined as this species, apparently not before reported from the United States, were made by Mr. Parks at Spruce Cove, Trinidad, Calif., in March, 1935, on *Sambucus racemosa* (5417) and *Lupinus rivularis* (5481-A) and in January, 1935, on *Heracleum lanatum* (5296). All of this material agrees with Weese's description<sup>2</sup> in dimensions, color, and the occasional presence of hyaline hairs around the margin of the perithecia. Weese's conclusion that *Charonectria Umbelliferarum* v. Höhn. occurring on Umbelliferae is probably identical with the similar species, *Charonectria Sambuci* v. Höhn., described on *Sambucus*, is therefore corroborated by the California collections. The specimen in the Mycological Collections of Rehm Ascomycetes no. 1867 (*Charonectria Umbelliferarum* v. Höhn. on stems of an umbellifer) unfortunately is immature. Another possible synonym suggested by Weese is *Nectriella dacrymycella* (Nyl.) Rehm; European material of this species, issued as Krieger Fungi Saxonici 1719, on *Cirsium arvense*, agrees with the California specimens, except for the deeper color of the apothecia. Rehm<sup>3</sup> is of the opinion that *Nectria Heraclei* Crouan and *Nectriella Umbelliferarum* (Crouan) Sacc. may also be identical with *Charonectria Umbelliferarum* v. Höhn. Weese points out other possible synonyms, but since type specimens have not been examined, he uses the name given by von Höhnel to the earlier of his two *Charonectria* species. *Nectria Sambuci* Ellis & Ev., an entirely different fungus occurring on *Sambucus*, is one of the many synonyms of *Creonectria purpurea* (L.) Seaver.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

## EXPLANATION OF FIGURES

Fig. 1. *Arachnopeziza Arctostaphyli* on *Arctostaphylos Tracyi*, Parks 5329, × 15; 2, *Belomidium Parksi* on *Castanopsis chrysophylla*, Parks 5455, × 5; 3, *Scleroderma lobata* on *Ribes Menziesii*, Parks 5472, × 5; 4, *Helotium cremeum* on *Pteridium aquilinum pubescens*, Parks 5514, × 5; 5, *Helotium nitens* on *Arctostaphylos Tracyi*, Parks 5530, × 5. Photographs made by M. L. F. Foubert.

<sup>2</sup> Ann. Myc. 12: 150. 1914.

<sup>3</sup> Ann. Myc. 7: 528. 1909.

## NEW OR NOTEWORTHY SPECIES OF RUSSULA AND LACTARIA

GERTRUDE S. BURLINGHAM

(WITH 8 FIGURES)

From November 1927 until late January 1928, and again from October 1934 until May 1935, it was my good fortune to collect fungi, especially of the genera *Russula* and *Lactaria*, in the vicinity of Seattle, Washington; Corvallis, Oregon; and in Pacific Grove, California. While much work remains to be done on this material, there are certain outstanding species which deserve immediate publication. I am also including in this article the description of a new species collected in Wyoming by the late Simon Davis, and notes on *Russula Mariae* Peck.

### ***Russula placita* sp. nov. (FIG. 1-4).**

Pileus fleshy, broadly convex then expanding, dark violet to vinaceous in the center, corinthian red to slate violet on the margin, pruinose in dry weather, very slimy viscid when wet, then glabrous, pellicle separable part way to the center, up to 10.5 cm. broad; margin coarsely striate tuberculate; context white except next the pellicle where it varies from corinthian red to slate violet, fragile, acrid, without special odor; lamellae white at first, becoming pale ecru, deepest colored on the edge, equal, mostly simple, ventricose, up to 1.2 cm. broad, narrowed toward the inner end, then rounded and depressed next the stipe and attached by a tooth, close, interveined, pruinose; stipe white but slightly yellowish in drying, spreading at the apex, spongy, 8.5 by 2-2.2 cm.; spores ochroleucous tone 1-2 in mass, broadly elliptical, apiculate, with scattered protuberances, some of which are connected by fine lines or bands, mostly  $7.5 \mu \times 8.75 \mu$ .

TYPE LOCALITY: Near Seattle, Washington.

HABITAT: Usually under Douglas fir, but sometimes under pines.

DISTRIBUTION: South Tacoma, Squaw Mountain, and various other places near Seattle, Washington; Corvallis, Oregon; and Pacific Grove, California.

Pileo carnosio, convexo-plano, jove pluvio viscoso, medio vinoso, margine livido, striato-tuberculoso; carne alba, fragili, acri; lamellis pallide gilvis, aequalibus, simplicibus, postice attenuatis sed proxime stipitem rotundatis, confertis; stipite albo, spongioso, 8.5 cm.  $\times$  2-2.2 cm.; sporis ochroleucis  $7.5 \mu \times 8.75 \mu$  (FIG. 1-A).

This species differs from both *Russula corinthiurubra* Burl. and *Russula atrovioleacea* Burl. in its more spongy texture, in the striate tuberculate margin, the band of striations sometimes reaching from 1 to 1.5 cm. in toward the center, in the attachment of the lamellae, and in the paler color and markings of the spores. It is one of the most abundant *Russulas* in the vicinity of Seattle during October.

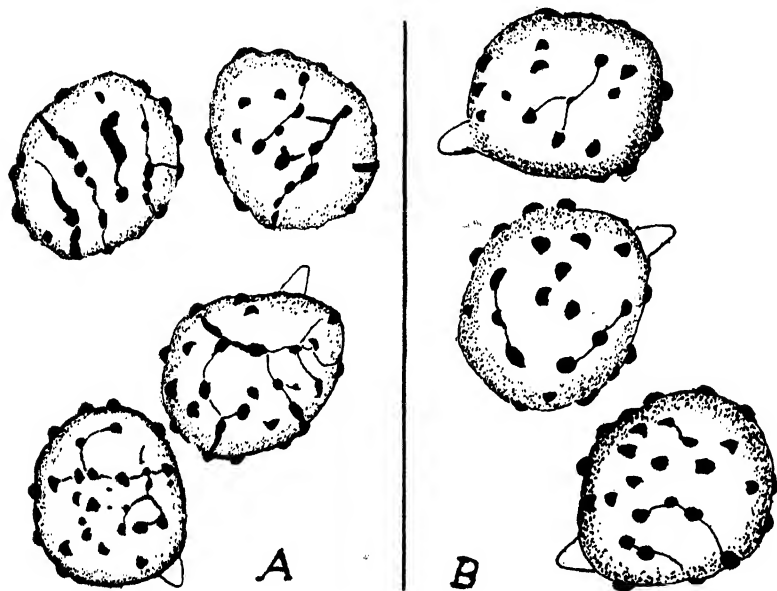


FIG. 1-A. Spores of *Russula placita*.

FIG. 1-B. Spores of *Russula murina*.

***Russula murina* sp. nov. (FIG. 1-B).**

Pileus broadly convex, becoming plane to centrally depressed, up to 7.5 cm. broad; surface light olive gray or deep olive gray in the center, slimy viscid when wet, pruinose when young, glabrous and shining over the marginal area when mature, rarely becoming granulose on the disc, cuticle separable more than half way to the center; margin becoming coarsely striate tuberculate for a width

of 1.5 cm.; context white, mild then slowly slightly acrid, decidedly so in young specimens, fragile; lamellae becoming pale ecru tone 4 to maize yellow tone 2, equal and mostly simple, rounded next the stipe and attached by a tooth, close, rather broad; stipe white, sometimes yellowish at the base, spreading at the apex, otherwise nearly equal, glabrous, 4.5 cm.  $\times$  1.3–1.5 cm.; spores yellow ochre (326 t. 2) with large protuberances varying in size, having a few connected by fine lines,  $7.5 \mu \times 10 \mu$  to  $7.5 \mu \times 8.75 \mu$ .

TYPE LOCALITY: Near Agate Beach Inn, Agate Beach, Oregon.

HABITAT: In dirt and needle soil under Douglas fir and lodge-pole pine.

DISTRIBUTION: The type locality and Newport, Oregon.

Pileo e convexo expanso depressoque, pruinoso, fragili, jove pluvio pellicula separabili viscosa, tunc demum margine polito, glabro, tuberculoso-striato, infrequenter disco granuloso, murino colore; carne alba, tarde acri; lamellis pallide ochroleucis, confertis, aequalibus, simplicibus; stipite albo, glabro; sporis ochroleucis,  $7.5 \mu \times 8.75 \mu$ – $10 \mu$ .

This species belongs in the group with *Russula gracilis* Burl. from which it differs in being less fragile, in the color of the pileus, in its less acrid taste, and in its habitat. In appearance in the field and in dried specimens, the two species are quite different.

### ***Russula inconstans* sp. nov. (FIG. 2-A).**

Pileus broadly convex becoming plane to centrally depressed, from 5.5 cm. to 13 cm. broad; surface corinthian red on the margin toning into pale reddish lilac, mineral brown to maize yellow over the center, or vandyke brown in the center when young, fading with age, slimy viscid when wet, cuticle separable half way to the center, glabrous; margin pruinose when young, becoming striate tuberculate on the edge; context white, unchanging, acrid in young specimens, slowly acrid in the adult stage, without special odor; lamellae white at first, becoming pale ecru tone 4 to maize yellow tone 2, some short, some forking near the stipe or near or part way to the margin, depressed near the stipe and attached by a tooth, close, not very broad; stipe white sometimes with yellow stains at the base, spreading at the apex, firm becoming spongy, 1.5–3.5 cm.  $\times$  6–8 cm.; spores ochroleucous,  $6.8 \mu$ – $7.5 \mu \times 7.5 \mu$ – $8.75 \mu$ , exclusive of the apiculus, reticulate banded with some protuberances and some fine connecting lines.

TYPE LOCALITY: Woodcock's Hill, Corvallis, Oregon, Nov. 14, 1927.

HABITAT: In needle soil under Douglas fir trees on the edge of woods.

DISTRIBUTION: In various localities near Corvallis, Oregon.

Pileo variegato, firmulo, explanato depressoque, jove pluvio viscoso, glabro; margine primum pruinoso, tum glabro, dein striatulo; carne alba, acri; lamellis ex albo gilvis, adnexis, confertis, immixtis brevioribus, furcatis; stipite albo, e firmo spongioso; sporis ochroleucis, reticulatis,  $6.8\mu-7.5\mu \times 7.5\mu-8.75\mu$ .

This species differs from *Russula placita* in the narrower forking lamellae, the firmer context, in the deeper yellow spores as well as in the color of the pileus and the less pronounced striate tuberculate margin. From *Russula maculata* Quél. it differs in the paler lamellae and the absence of red or bistre on the stipe, and in having smaller ellipsoid and reticulate banded spores.

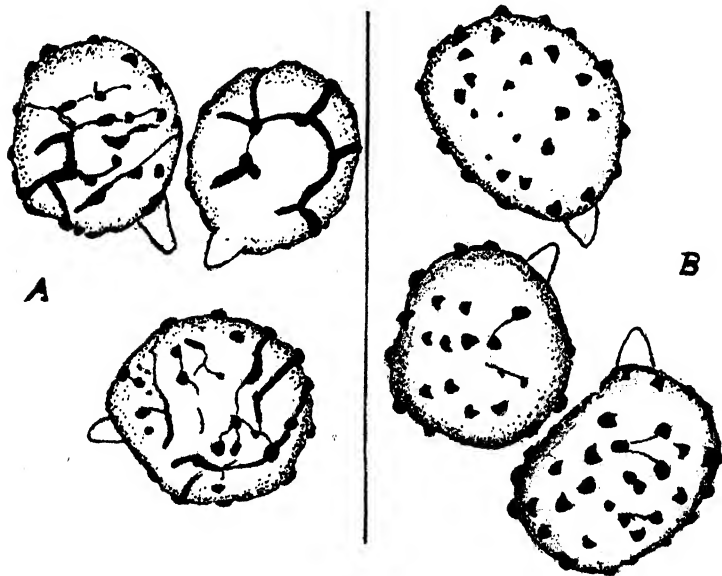


FIG. 2-A. Spores of *Russula inconstans*.

FIG. 2-B. Spores of *Russula Zellerii*.

***Russula Zellerii* sp. nov. (FIG. 2-B).**

Pileus convex becoming plane then somewhat centrally depressed, up to 9 or more cm. broad; surface anthrocene purple to

taupe brown at the center, becoming in mature specimens vinaceous lilac to deep purple vinaceous at the margin and taupe brown<sup>1</sup> at the center, slimy viscid when wet, with separable tough cuticle, glabrous; margin soon striate, becoming coarsely striate tuberculate for 2 cm. toward the center, thin; context white, unchanging, fragile, pleasantly mild; lamellae fleshy white becoming pale ecru tone 2 when mature, equal, a few forking near the margin, venose connected, broad, rather distant, rounded at the outer end, narrowed at the inner end and attached by a line, appearing nearly free; stipe white, unchanging, tapering upwards, glabrous, 1-1.5 cm. by 5-6 cm.; spores maize yellow tone 2, ellipsoid, echinulate, apiculate, unsymmetrical,  $7.5-8\ \mu \times 8.75-9.3\ \mu$ , rarely with a few connecting lines between scattered protuberances of various sizes.

TYPE LOCALITY: Campus of Oregon State College at Corvallis, Oregon. Type No. 7170 in part in the herbarium of the Oregon State College, and in part in the author's herbarium.

HABITAT: On clay soil in grass and moss under *Picea sitchensis*.

Pileo e convexo plano-depresso, viscoso, vinaceo, 9 cm. lato; margine livido demum lilacino, striato; lamellis ex albo pallidis, aequalibus, subliberis, confertis, latis, subdistantibus, antice furcatis; carne alba, miti, fragilissima; stipite albo, glabro, sursum attenuato, 1-1.5 cm.  $\times$  5-6 cm.; sporis pallide alutaceis (Repertoire de Couleurs pl. 36 t-2), echinulatis,  $7.5-8\ \mu \times 8.75-9.3\ \mu$ .

This is a beautiful species distinguished by the mild taste, thin flesh of the pileus and the broadly striate margin. It is fragile especially when mature. From *Russula integra* (L.) Fries it differs in its more fragile context, vinaceous color, and in the shape and markings of the spores. From *Russula puellaris* Fries, it differs in its larger size, the absence of yellowish stains on the stipe, the free and more distant lamellae, and the larger ellipsoid spores. The average size of the pileus in adult specimens is about 9 cm., but the extreme size reaches 15 cm. in diameter. The type collection was made on Nov. 28, 1927 by Dr. S. M. Zeller, and another on Dec. 5, 1927. And from the same locality I secured another collection in November.

***Russula marginata* sp. nov. (FIG. 3-A).**

Pileus broadly convex becoming expanded and centrally depressed, up to 12 cm. broad; surface sordid white on the center

<sup>1</sup> Ridgeway.



with pinkish-bluish<sup>2</sup> tints on the margin, viscid when wet, pellicle separable on the margin, glabrous; margin even to striatulate, involute; context fleshy, firm, white, instantly acrid, but not persisting, odor unimportant; lamellae white becoming a little ochraceous with age, equal or with a few short ones, many forking, brittle, close, rounded at the outer end, narrowed at the stipe; stipe white, discolored with handling, equal or tapering upwards from below the middle, and abruptly tapering at the base, making it ventricose to subventricose, becoming hollow, up to 3.75 cm.  $\times$  6 cm.; spores ochroleucous, ellipsoid, apiculate, with scattered protuberances of varying size, some connected by bands or fine lines, unsymmetrical,  $5.6\text{--}6.2\ \mu \times 8.75\text{--}10\ \mu$ .

TYPE LOCALITY: Z/T Ranch, Rock Creek, Wyoming. No. 2 of July 17, 1920, Simon Davis, collector.

HABITAT: Under greasewood, gregarious.

DISTRIBUTION: Several collections from near the type locality.

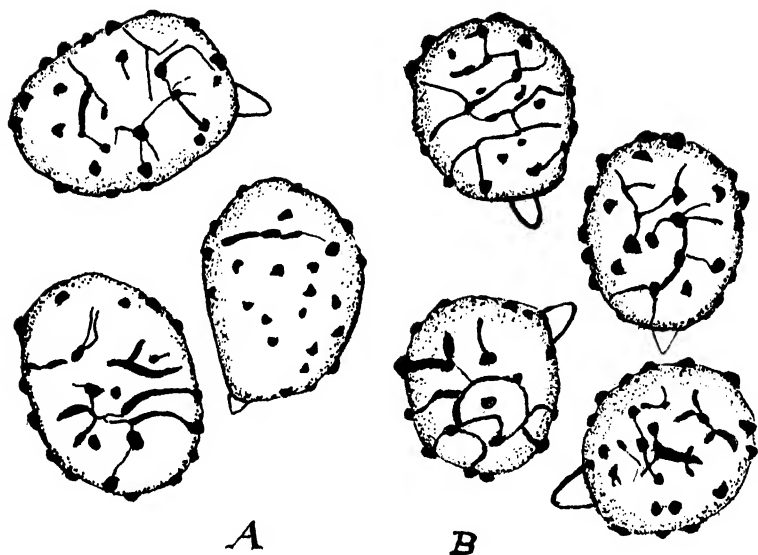
Pileo convexo-explanato depressoque, disco sordide albo, margine livido, joye udo viscido; margine involuto, levi, dein striatulo; carne alba, firma, acri; lamellis ex albo subochraceis, subaequalibus, furcatis postice attenuatis, confertis; stipite albo, tacto ochroleucescente, aequali ventricosove, e farcto cavo, glabro; sporis ochroleucis,  $5.6\text{--}6.2\ \mu \times 8.75\text{--}10\ \mu$  (FIG. 3-A).

In dried specimens the color of the margin of the pileus varies from atrovioletaceous to bluish lilac and corinthian red, while the center varies from putty color to snuff brown, sometimes with a dull greenish tint, the stipe becomes ochroleucous. This species differs from *Russula atrovioletacea* Burl. in being instantly but not lastingly acrid, the marginal band of color surrounding the sordid white center, and the discoloring of the stipe with handling or in drying, while the spores are paler and ellipsoid.

***Russula mordax* sp. nov. (FIG. 3-B).**

Pileus broadly convex, expanding and somewhat centrally depressed with drooping margin, up to 13 cm. broad; surface blood-red brown to madder brown, viscid but not slimy when wet, cuticle separable half way to the center, flesh white underneath; margin even; context white, unchanging, without odor, very acrid; lamellae maize yellow tone 1, equal, many-forking near the stipe and a few near or part way to the margin, intervened, rounded at the outer end, abruptly narrowed next the stipe, close; stipe washed

<sup>2</sup> According to terminology of Simon Davis; probably lividus.

FIG. 3-A. Spores of *Russula marginata*.FIG. 3-B. Spores of *Russula mordax*.

with red, more deeply colored in same places, paler at the junction with the lamellae, nearly equal, blunt at the base, 8 cm. by 3 cm.; spores ochroleucous in mass,  $6.5-7.5 \mu \times 7.5-8.75 \mu$ , with protuberances of varying size, many connected by bands or fine lines, apiculate.

TYPE LOCALITY: Seward Park, Seattle, Washington.

HABITAT: Under Douglas fir in a rather open place, November.

Pileo convexo explanato subdepressoque, ex latericio sanguinco-brunneo, jove pluvio viscido; margine reflexo, levi; carne alba, immutabili, sine odore, acerrima; lamellis aequalibus, furcatis, venoso-connexis, postice attenuatis, confertis; stipite rubello, subaequali,  $3 \times 8$  cm.; sporis ochroleucis,  $6.5-7.5 \mu \times 7.5-8.75 \mu$ .

This species differs from *Russula badia* Quél., in the taste being instantly acrid, the lamellae not sinuate, in the lack of odor, and in the color, shape, size and markings of the spores. From *Russula tenuiceps* Kauff., it differs in the even margin, the closer lamellae, firmer texture, the paler, reticulate spores. The habit is not gregarious. In color it resembles *Russula astringens* Burl.

Only the type collection has been made but the information secured was so complete and decisive and the condition when dried so good that one would have no difficulty in recognizing the species.

**LACTARIA OBNUBILA** (Lasch) Fries (FIG. 4-A).

Pileus very thin, plane with a slight papilla, then infundibuliform, up to 4 cm. broad; surface raw umber tone 4 or sepia to snuff brown, paler toward the margin, azonate, viscid when wet but not slimy; margin even at first becoming striate-tuberculate half way to the center; context fragile, odorless; latex white, unchanging, mild; lamellae dark fawn (307 t. 1-4), unequal, a few forking next the stipe, close, slightly decurrent; stipe burnt umber (304) to mineral brown (339 t. 4), brightest colored and tomentose at the base,  $.7 \times 4.5$  cm.; spores white, reticulate, with raised bands and protuberances,  $7.5-8.75 \mu \times 8.75-10 \mu$ , broadly elliptical, apiculate, unsymmetrical.

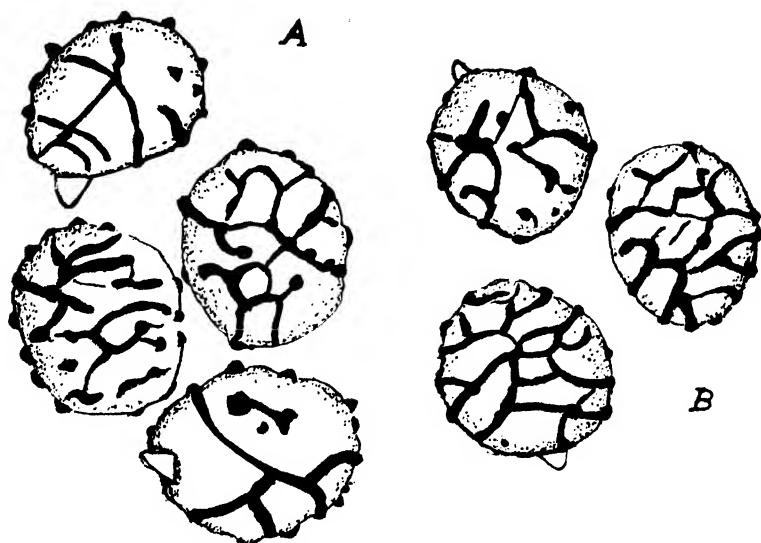
**HABITAT:** In moist black soil under alders (*Alnus oregona*) or on alder wood.

**DISTRIBUTION:** In several localities in the vicinity of Seattle, Washington, and near Rhododendron, Oregon.

In Nov. 1927 Dr. Hotson found specimens of this species under alders in a moist ravine on the campus of the University of Washington at Seattle. In September 1931 Dr. J. E. Lange and Dr. S. M. Zeller collected specimens under alders at Rhododendron, Oregon. In Nov. 1934 Daniel Stuntz collected the species in several localities outside of Seattle, Washington, and I found it growing abundantly in an alder bottom near the campus of the University of Washington on October 29. The accompanying photograph was made of specimens from this collection. Since no description of this species occurs in our literature, I have included a full description. While the latex is mild, there is a slight astringent taste to the flesh when chewed. Dr. Lange has seen specimens of the Washington collection from which the photograph was made and considers the species the same as *Lactarius obnubilis* which he has described in "The Agarics of Denmark."

**Lactaria luculenta** sp. nov. (FIG. 4-B).

Pileus broadly convex or almost plane with inrolled margin, slightly papillate becoming centrally depressed with the papilla dis-

FIG. 4-A. Spores of *Lactaria obnubila* (Lasch) Fries.FIG. 4-B. Spores of *Lactaria luculenta*.

appearing, up to 7.5 cm. broad; surface isabelline tone 1-3 when moist in the field, pitchpine to brownish terra cotta (322 t. 1-4) as the viscosity disappears, slimy viscid when wet, glabrous; margin even becoming slightly striate on the very edge when mature; context pale flesh tone 4, a little bitter then slowly acrid; latex white, unchanging, a little astringent, mild or tardily making the tongue sting slightly; lamellae cinnamon tone 1 singly, isabelline in position, unequal, simple, adnate to decurrent by a tooth, close; stipe isabelline to fawn or brownish terra cotta, slightly deeper colored toward the base, firm, becoming hollow, .7-1.5 cm.  $\times$  2-5 cm.; spores fleshy white, ellipsoid, with reticulate bands and some protuberances,  $6.25-6.87 \mu \times 7.5-8.1 \mu$ .

TYPE LOCALITY: Woodcock's Hill, Corvallis, Oregon.

HABITAT: Under Douglas fir. Gregarious.

DISTRIBUTION: In various localities around Corvallis, Oregon, and in Muir Woods, California.

Pileo e papillato convexo, explanato depressoque, viscoso, azono, isabellino vel cinnemoneo, glabro, 3.5-7.5 cm. lato; carne isabellina, tarde acri; lacte albo, submiti; lamellis isabellinis, inaequalibus, adnatis vel subdecurrentibus; stipite isabellino vel fulvo, e farcto cavo, glabro, 1-1.3 cm.  $\times$  2-5 cm.; sporis albidis, reticulatis, ellipsoidis,  $6.25-6.87 \mu \times 7.5-8.1 \mu$ .

This species belongs in the group with *Lactaria aurantiaca* Fries, but differs in being slimy viscid when wet, the lamellae scarcely decurrent, the latex scarcely acrid although the flesh makes the tongue sting slightly when it is thoroughly chewed, and the color of the pileus is paler, verging more on yellow than orange while the spores are a little smaller and more reticulate. This has probably been reported as *Lactaria mitissima* Fries from which it differs in the slimy viscosity of the pileus and the slight acidity of the context. According to Fries, the pileus of *Lactaria mitissima* should be dry, the latex mild as the name implies, the taste rarely somewhat bitter, and the habitat principally in deciduous woods.

**Russula Californiensis** sp. nov. (FIG. 5-A, 8).

Pileus broadly convex, expanding, becoming centrally depressed with margin arched or spreading, rather firm, 8.5 to 24 cm. broad; surface old-blood red to peach red or coppery red, sometimes Naples yellow over the center, viscid when wet, with the cuticle separable half way to the center, glabrous; margin even or sometimes obscurely coarsely striate tuberculate on the extreme edge when mature; context white, becoming pale gray especially in the stipe as it begins to dry or with age, acrid when young, less so with age, with no special odor; lamellae flesh color tone 4 singly, pale ecru tone 4 in position, equal, many forking near the stipe, a few elsewhere, interveined, rounded at the outer end, gradually narrowed toward the inner end, then depressed near the stipe and attached by a tooth, close, acrid at all ages; stipe white becoming pale gray with age or in drying, firm, usually 1.3-4 cm. by 8-10 cm., extreme size 5.5 cm. at the base, 7.5 cm. at the apex by 18 cm. in length, varying in shape but inclined to be ventricose, stuffed; spores honey yellow tone 1 to 2, covered with protuberances of varying size and shape, often connected by fine or thicker lines giving them a reticulate appearance,  $7.5-8.75 \mu \times 9-10 \mu$ .

TYPE LOCALITY: Pacific Grove, California.

HABITAT: Under Monterey pine and California live oak.

DISTRIBUTION: Common in various localities in the vicinity of Pacific Grove, California.

Pileo firmo, convexo-explanato, depresso, glabro, jove pluvio viscido, pellicula subseparabili, sene-sanguinea pallidioreve, 8.5-25 cm. lato; margine reflexo patenteve, levi, infrequenter leviter striato-tuberculoso; carne alba, fracta tarde subcinerascente, acri; lamellis pallidis, aequalibus, postice

furcatis et attenuatis sed proxime stipitem rotundatis et adnectis dente, venoso-connexis, confertis; stipite albo tarde cinerascete cum siccescit, inaequali, farcto, 1.3-4 cm.  $\times$  8-18 cm.; sporis melleis,  $7.5-8.75 \mu \times 9-10 \mu$ , reticulatis.

This species differs from the other species in the *Veternosae* group in the change of the color of the surface of the stipe and the context from white to pale gray with age or as the mushroom dries. The gray stipe is very noticeable in the field in dry weather as the mushroom reaches maturity. The gray color is not prominent when the specimens are finally dried. The acrid taste separates it from the red capped species with flesh becoming gray. The acidity is most pronounced in the lamellae where it persists. During December and January this was the most abundant species in the woods around Pacific Grove. In size and bright coloring it is so typical of California that the specific name given seems appropriate.

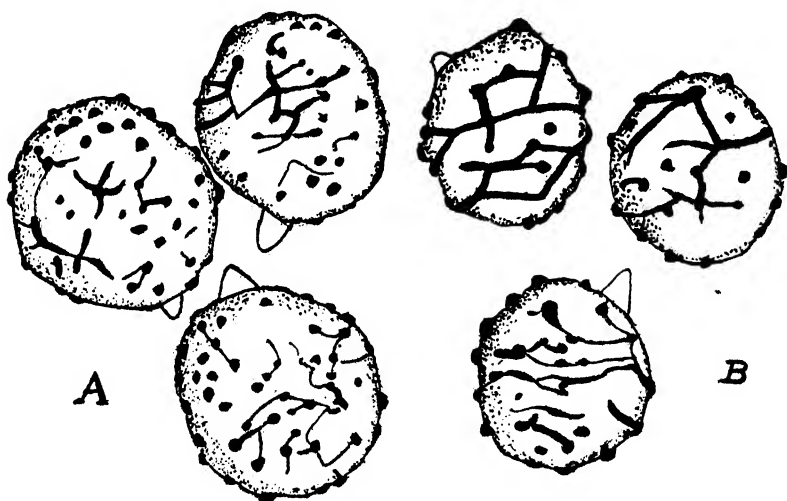


FIG. 5-A. Spores of *Russula Californiensis*.

FIG. 5-B. Spores of *Lactaria rufula* Peck.

*LACTARIA RUFULA* Peck (FIG. 5-B).

This species has previously been reported only from California. It occurs abundantly in spruce woods near Agate Beach Inn, Agate Beach, Oregon, during November. It differs from *Lactaria rufa*

(Scop.) Fries in the thinner pileus, with a fluted and sometimes striate margin, absence of an umbo, the more slender stipe, the adnate lamellae, and the latex being slowly acrid with sometimes a bitter taste at first. The spores from specimens of *Lactaria rufa* which I collected in Sweden are smaller and have finer lines connecting the protuberances. The surface of *Lactaria rufula* is slightly viscid in wet weather.

RUSSULA ROMELLII Maire (Bull. Soc. Myc. Fr. 26: 107. 1910.  
*fig. 1* (FIG. 6-A).

This species is closely related to *Russula alutacea* from which it differs chiefly in the spore markings. It was collected Dec. 27, 1927 in pine woods at Pacific Grove, California. It has not been previously reported from the United States. The specimens agree in all respects with specimens which I collected in Sweden in 1930. The pileus was vinaceous on the margin fading with age, maize yellow in the center, viscid when wet, with the margin becoming striate tuberculate on the extreme edge. The lamellae were pallid at first, then yellow, close, some forking near the inner end, and attached; the spores are ochraceous,  $7.5 \times 8.75 \mu$  to  $8 \times 10 \mu$ , reticulate. The stipe was white in all specimens collected.

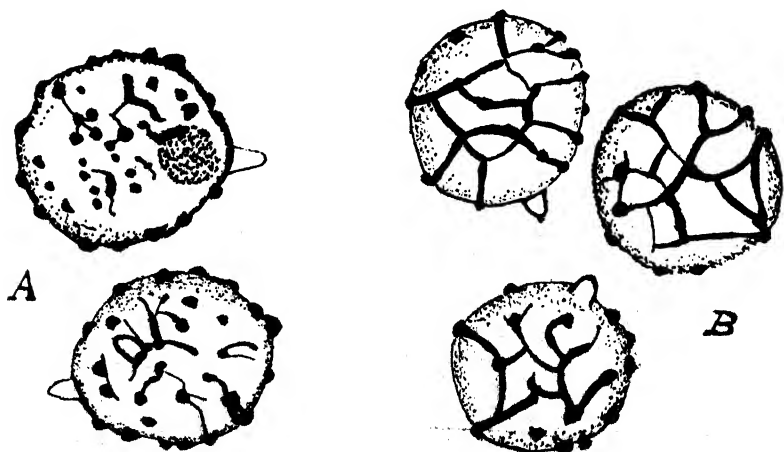


FIG. 6-A. Spores of *Russula Romellii* Maire.

FIG. 6-B. Spores of *Russula Mariae* Peck.

## RUSSULA VESCA Fries.

Specimens of this species were collected near Waldport, Oregon (6 Nov. 19—'34), and on the Beach Road between Newport and Agate Beach, Oregon (8 Nov. 27—'34). It has not been previously reported from the Pacific Coast. It is characterized by the mild taste, white spores, and reddish or Van Dyke brown pileus. In *Hymenomycetes Europaei* and other publications Fries classed *Russula vesca* with the *Heterophyllae*, but in his painting which I examined in Stockholm the lamellae are plainly equal. Specimens which I collected around Upsala all showed the equal lamellae and were almost exactly the color of the species which I described as *Russula brunneola* (N. Am. Flora 9<sup>4</sup>: 233). While the painting by Fries shows a red pileus, the color seems more often to verge into some shade of brownish red. The spores of *Russula brunneola* are like those of *Russula vesca*, and there seems no doubt that *Russula brunneola* becomes a synonym of *Russula vesca* Fries. The spores agree in markings with those shown in Pl. IX in *Spore Ornamentation of the Russulas* by R. Crawshaw. The lamellae are inclined to have rusty colored spots.

## RUSSULA SANGUINEA (Bull.) Fries.

This species characterized by the blood-red pileus and the stipe usually tinted more or less with the same color, while the lamellae are white with pale yellow spores (pale ecru tone 4 to honey yellow tone 1 in mass) and the acrid taste was collected south of



FIG. 7. *Lactaria obnubila* (Lasch) Fries.



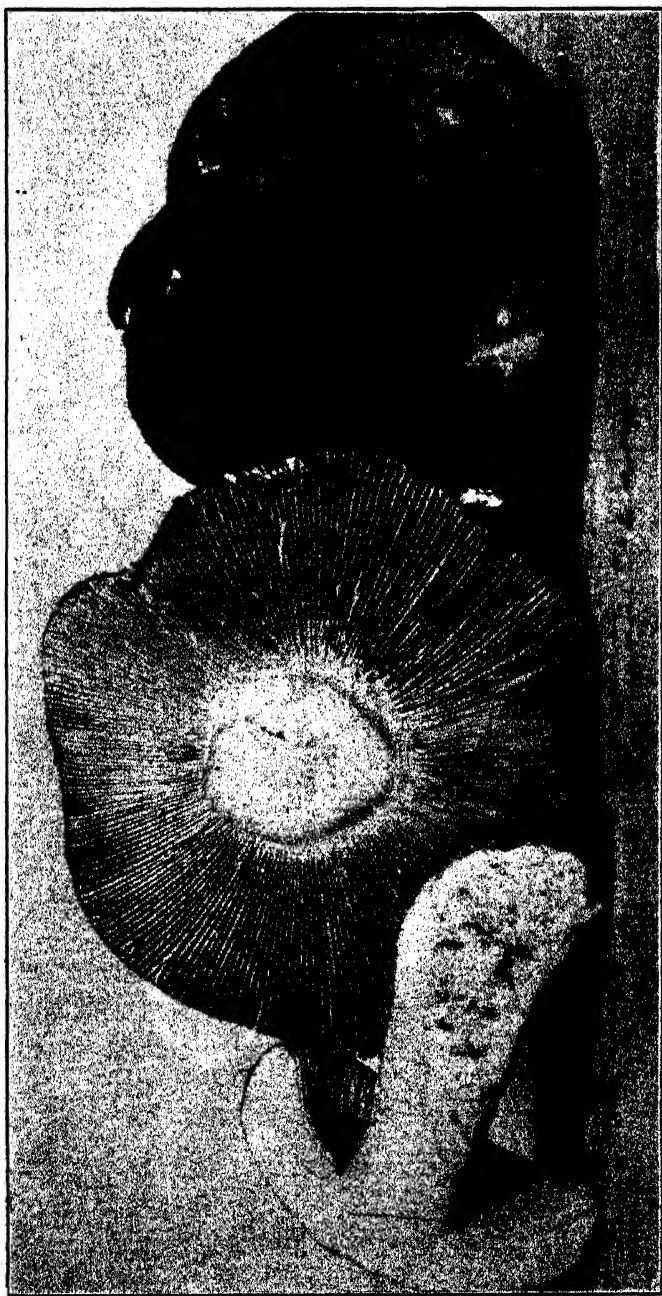


FIG. 8. *Russula Californiensis* Burl.

Meadowdale, near Seattle, Washington, by David Stuntz (No. 2 Oct. 11—'34). I collected it at Newport, Oregon, under lodge-pole pines (No. 1—Nov. 17—'34); under pines south of Corvallis (6 Nov. 16—'27), and under Monterey pines at Pacific Grove, California (11 Jan. 4—'35).

RUSSULA MARIAE Peck (FIG. 6-B).

In the Annual Report of the N. Y. State Museum 24: 74. 1872, Dr. Peck described *Russula Mariae*. In 1880 Quelet described *Russula amoena* in Ass. Fr. Avais. Sc. 9: 8. Specimens of the latter sent me by Julius Schaeffer seem to be identical with Peck's species, even to the spore ornamentation. Maire considers *Russula amoena* to be the same as *Russula punctata* Gill. Champ. Fr. 245. 1879. I have not seen specimens of *Russula punctata*, but *Rusula amoena* is without doubt synonymous with *Russula Mariae*, and if Maire is correct in his determination, Gillet's species is also reduced to the same synonymy.

The spore drawings have been made with the aid of a camera lucida, using an iodine solution prepared according to the formula of Crawshay. Unless otherwise stated the colors given in descriptions are those found in the Repertoire de Couleurs. Specimens of the types and other species included in this article have been placed in the herbarium of The New York Botanical Garden, and with the exception of *Russula mordax*, in my herbarium. Excepting also the latter species, specimens have been filed in the herbarium of the University of Washington in Seattle, and that of the Oregon State College at Corvallis.

I am much indebted to Dr. J. W. Hotson of the University of Washington and to Dr. S. M. Zeller of the Oregon State College for supplying facilities for studying and drying specimens and for assistance in collecting.

# FALSE MILDEW OF RED MULBERRY

FREDERICK A. WOLF

(WITH 3 FIGURES)

For several years the writer has been interested in a survey of the plant diseases that occur within the area comprising the Duke Forest. Among the diseases to which special study has been devoted is one that involves the foliage of the red mulberry, *Morus rubra* L., to which name false mildew may be appropriately applied. Its causal agency, both in its conidial and its perithecial stage, appears to be specifically distinct from any fungi that have been reported to occur on *Morus*, and in consequence, consideration has been given to its morphology and cycle of development. The results of this study on the false mildew organism are herein assembled as a further contribution to our knowledge of the diseases affecting trees within the Duke Forest.

## APPEARANCE OF THE DISEASE

As indicated by the term false mildew, this disease is characterized by the presence of an effuse, white, cob-webby coating that simulates the appearance of a powdery mildew (FIG. 1, 2). It is first apparent during July when scarcely-evident, whitish, indefinitely-limited patches may be noted on the under sides of the leaves. At this stage, there is little if any apparent discoloration when affected leaves are viewed from the upper leaf surface. By the time that the whitish patches are one-quarter to one-half inch or more in diameter, however, yellowish areas are discernible on the upper side. These areas become necrotic early in autumn and large irregular brownish spots are then present.

## THE CONIDIAL STAGE

Upon microscopic examination it becomes apparent that the whitish coating is imparted by the superficial, reproductive mycelium together with the profusion of conidia. The reproductive

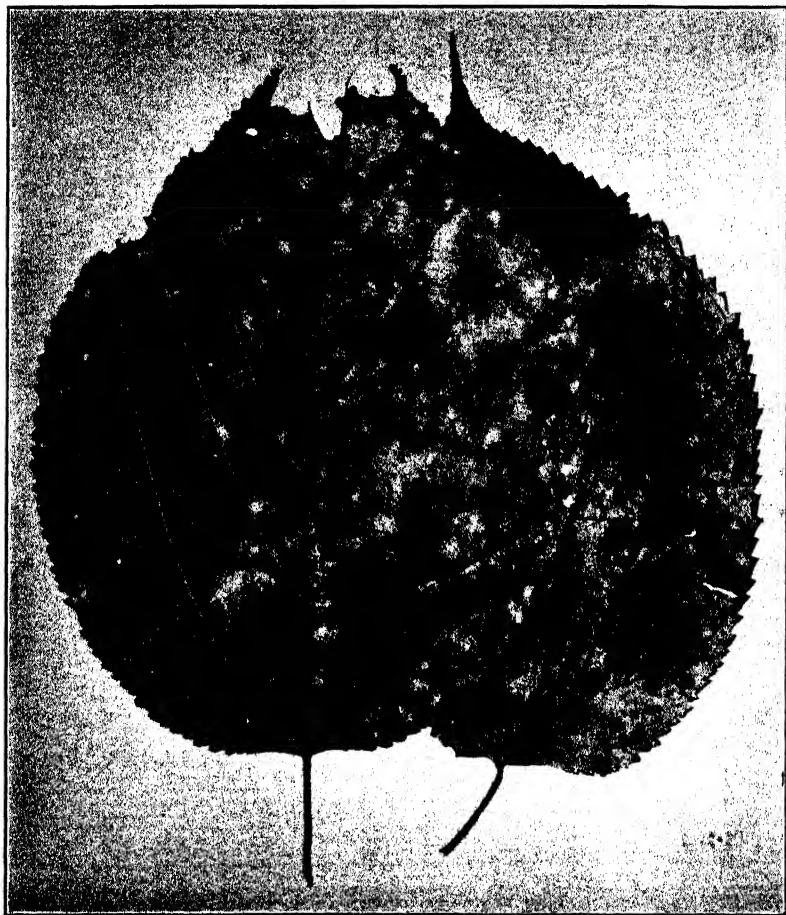


FIG. 1. Leaves of red mulberry, showing effuse whitish areas on the lower leaf surface, caused by *Cercospora arachnoidea*.

mycelium, emerges from the stomates. It courses over the leaf surface forming a closely appressed, branched, tangled, hyphal weft, and is dependent for its nourishment upon the internal, intercellular mycelium. At intervals short knob-like, lateral branches arise singly from the reproductive hyphae. These lateral branches function as conidiophores (FIG. 3, *B*). Each conidiophore produces acrogenously a quantity of conidia that arise singly and are dislodged at maturity. The conidia are hyaline, septate, blunt-pointed, and range in size from  $40-70 \times 3.75-4.5 \mu$  (FIG. 3 *A*).

The morphological features of the organism under consideration are similar generically to those of a widely known pathogen on peach, *Cercospora persica* Sacc., the type upon which the genus *Cercospora* is based. Attention may be directed to the fact that the description of *C. persica* in Saccardo's *Sylloge Fungorum* (4: 218) is inadequate and that our knowledge of its morphology has been clarified by the investigations of Tsuji (3).

#### THE PERITHECIAL STAGE

Examination of leaves, collected during October, shows that the perithecial stage is initiated just prior to the abscission of the leaves. The surface of the necrotic tissues, at this time, may be noted to be densely occupied on the upper leaf surface by dark spermogonial and perithecial primordia. Both structures may be intermingled, however, on both leaf surfaces. The spermogonia are at first dense, spherical stromata wholly embedded within the leaf. Spermatial formation is initiated by the disintegration of the innermost cells of the stromata, a process which proceeds centrifugally. Eventually the spermatia entirely fill the spermogonial cavity. The wall, at maturity, is a single cell-layer in thickness. The spermogonia range in size from 40 to 65  $\mu$ . The spermatia are rod-shaped, hyaline, and measure approximately  $4 \times 1.25 \mu$ , fig. 3, *D*.

In order to study the development of the perithecia affected leaves were collected and piled in a suitable location on the forest floor. Some of these leaves were examined at intervals throughout the winter and spring and as a result it was found that the perithecia are mature by May.

In the early stages, perithecial primordia are morphologically indistinguishable from spermogonial primordia. After spermatial production has ceased, however, they remain as compact stromata whose innermost cells have a deeply-staining content. By spring the perithecial stromata will have enlarged to the extent that they project about half their height above the surface of the decaying leaves (FIG. 3, *H*). At this stage, as seen with low magnification, they appear as black points, densely aggregated into black patches, hundreds being present in an area one or more centimeters across. Mature perithecia vary from 80–100  $\mu$  in diameter. They open

by means of a perforation through a short papilla. Their wall is constituted of a thin layer of brown-walled cells. If the perithecia are crushed in a drop of water on a microscopic slide, the asci may be seen to adhere in a fascicle. No paraphyses are present. The asci measure  $45\text{--}54 \times 7\text{--}8.5 \mu$  (FIG. 3, G). The ascospores are arranged biserially, are hyaline, 2-celled, curved, and measure  $14\text{--}17 \times 3.5\text{--}4 \mu$ , the upper cell being slightly longer and wider than the lower (FIG. 3, E).

The structural features of the perithecia of this organism on mulberry leaves, as just described, are manifestly those of the genus *Mycosphaerella*. The connection of the *Mycosphaerella* stage with the *Cercospora* stage that preceded it is based upon evidence (1) from cultures and (2) from inoculation experiments.

Cultures were isolated both from conidia and from ascospores. Isolations from conidia were obtained by the dilution method in potato agar plates, using a watery suspension of conidia as inoculum. Isolations from ascospores were obtained by permitting the ascospores to be forcibly ejected onto inverted potato agar plates. The colonies that develop on this substratum are slow-growing, rather compact, and white to faintly pink. No evidence of conidial production in cultures has been noted. The colonies that originate from conidia, however, are entirely like those originating from ascospores.

Since the organism could not be induced to fruit in culture it was impossible to use pure cultures for inoculations. In consequence it was necessary to use leaves bearing perithecia, as inoculum. Fragments of such leaves were accordingly applied to healthy mulberry leaves. The inoculum was held in place by means of bits of paper towels, that served, in addition, in keeping the inoculum moist after rains. Three to four weeks after inoculation a whitish coating consisting of mycelium and conidia was present on the inoculated leaves. Upon examination these conidia were found to be morphologically identical with those of the *Cercospora* that had been originally observed to be pathogenic to red mulberry.

## IDENTITY OF THE PATHOGEN

Two species of *Cercospora* have previously been reported to occur on mulberry, *C. Mori* Peck, and *C. maculans* (Bereng.) Wolf. The former was first collected, in Texas, on *Morus alba*, by Heald and Wolf (2), and specimens were sent to Peck for identification. He named the fungus but did not describe it. The description was subsequently prepared by Heald and Wolf (2). The latter species as it occurs on red mulberry was recently studied by Wolf (1) and found to possess a perithecial stage, *Mycosphaerella Mori* (Fuckel) Wolf. Both of these species of *Cercospora* cause the formation of definite-margined leafspots, both bear conidia that are abstricted from small fascicles of conidiophores that emerge from the stomates; and both produce conidia that are pink en masse. The *Cercospora* under consideration is obviously distinct from both of these species. A search among the collections in the Farlow Herbarium, Harvard University and among those of the Mycological Herbarium of the United States Department of Agriculture has disclosed nothing on mulberry and closely related species that is identical with this false mildew fungus. Apparently it has never been described. The conidial stage is accordingly designated *Cercospora arachnoides*, a name which appropriately characterizes the gross appearance of the fungus on affected leaves.

Four species of *Mycosphaerella* (*Sphaerella*) are known to occur on species of *Morus*. In order to facilitate comparison of these four species with the false mildew fungus, the following tabulation has been arranged.

In explanation, it may be stated that *Sphaerella Mori-albae*, for which no measurements are recorded,<sup>1</sup> is synonymous with *Sphaeria Mori-albae* Schw. Its perithecia are borne on the lower leaf surface, and in addition, they are large and are grouped in small irregular areas. It is therefore, entirely unlike the false mildew organism. Both *Sphaerella morifolia* and *Mycosphaerella Mori* are obviously clearly distinct from the organism under consideration but it bears a close resemblance to *M. moricola*. *M. moricola* is not included in Saccardo's *Sylloge Fungorum* but was described,

<sup>1</sup> Sacc. Syll. Fung. 2: 438; Oudemans, Enum. Syst. Fung. 2: 901.

TABLE I  
COMPARISONS OF SPECIES OF MYCOSPHAERELLA ON *Morus* spp.

Organism	Location of perithecia	Perithecial size $\mu$	Ascal size $\mu$	Size of ascospores $\mu$
<i>Sphaerella morifolia</i> Pass.....	Hypophyllous	....., .....	50-55 $\times$ 10-15	17-25 $\times$ 5.0-5.5
<i>Myrosphaerella moricola</i> Sawada.....	Hypophyllous	36-75 $\times$ 32-71	28-43 $\times$ 8-10	16-18 $\times$ 3.5
<i>Mycosphaerella Mori</i> (Fkl.) Wolf.....	Epiphyllous	60-80	35-40 $\times$ 55-6.5	12-14 $\times$ 3.5-4
<i>Sphaerella Mori-albae</i> Cooke.....	Hypophyllous	.....	.....	.....
False mildew fungus.....	Amphigenous, mostly epiphyllous	80-100	45-54 $\times$ 7-8.5	14-17 $\times$ 3.5-4



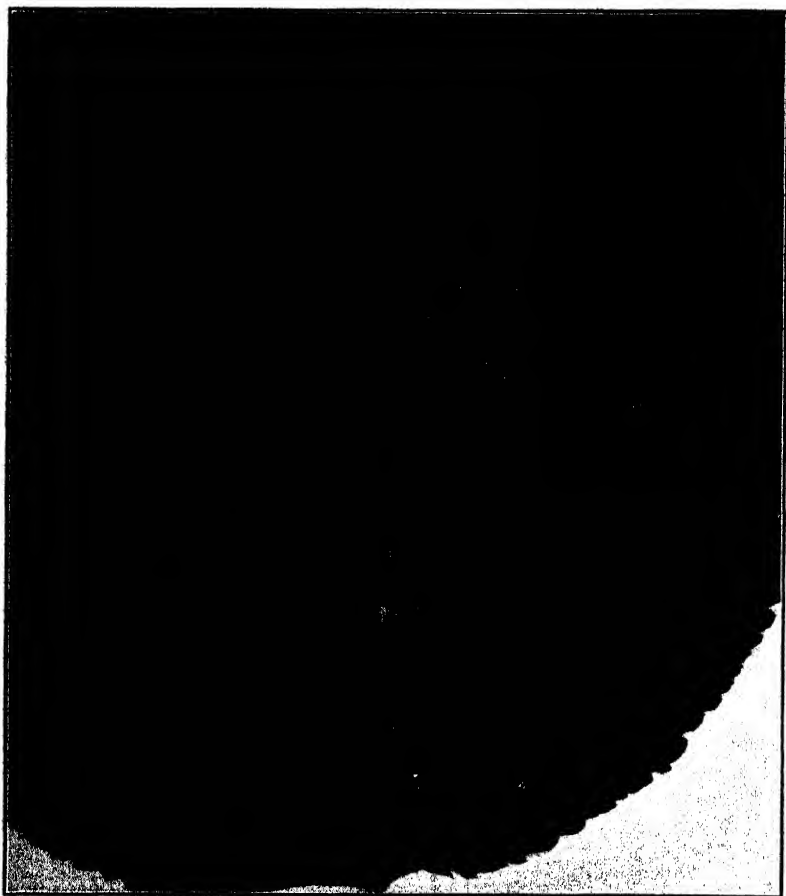


FIG. 2. Slightly enlarged view of a diseased leaf bearing lesions coated with *C. arachnoidea*. The gross appearance is that of a powdery mildew.

in 1919, in the Japanese language.<sup>2</sup> It has thus far been impossible to secure type specimens of *M. moricola*<sup>3</sup> and thus to make a

<sup>2</sup> Sawada, K. Descriptive catalog of the Formosan fungi. Part 1, 94-95, 1919.

<sup>3</sup> I have been able to examine specimens of *M. moricola*, through the efforts of Dr. G. D. Darker, since this manuscript was prepared. These specimens were collected in Formosa, on May 10, 1909, by Sawada. They show perithecia formed sparingly on the lower surface of lesions on green leaves of *Morus alba*. *M. moricola* is therefore specifically distinct from *M. arachnoidea*.

proper comparison. Evidently *Sphaeria moricola* Ces. represented in exsiccati, in Rabenhort's H. M. I. No. 1561, 1851, is antedated by *Sphaeria moricola* Schw. that has been set aside as a nomen nudum.

Whether *Mycosphaerella moricola* possesses a conidial stage is unknown since none is mentioned in Sawada's account.<sup>2</sup> The position and size of perithecia of *M. moricola* and the false mildew fungus differ, although the sizes of their asci and ascospores are quite in accord. Less confusion would appear to result at this time, since the developmental cycle of *M. moricola* is unknown, and comparison of specimens has not been possible, were the false mildew to be regarded as specifically distinct. It is therefore given the new specific name *arachnoidea* to indicate the powdery mildew-like character of the conidial stage. The name *erysiphioidea* would have been preferred were it not already preempted. ***Mycosphaerella arachnoidea* sp. nov.**

*Syn. Cercospora arachnoidea nom. nov.*

Peritheciis dense aggregatis, in maculis majusculis, amphigenis vulgo epiphyllis, erumpenti-superficialibus, atratis, papillatis, membranaceis; ascis base fasciculatis, aparaphysatis, oblongo-clavatis, octosporis,  $45-54 \times 7-8.5 \mu$ ; ascosporis biseriatis, curvulis, uniseptatis, constrictis, leniter inaequalibus, loculo superiore longiore atque crassiore,  $14-17 \times 3.5-4.0 \mu$ .

Hab. in foliis dejectis atque putridis, *Mori rubrae*, in verno.

Status spermogonicus: Stromatibus spermogonicis in autumnno efformantis, dense gregariis, plerumque epiphyllis; spermogoniis initio pseudoparenchymaticis, intus loculo spermogonico oriunde,  $40-65 \mu$ ; spermatiis bacilliformibus, hyalinis,  $4.0 \times 1.25 \mu$ .

Status conidicus: Statum conidicum *Cercospora arachnoidea* sistit. Maculis flavescentibus deinde brunneis; fertile mycelio erysiphioideo, ectophytico, hypophyllo; conidiophoris bursiformis, apice conidia gerentibus; conidiis vermicularibus, pluriseptatis, guttulatis, hyalinis,  $40-70 \times 3.75-4.0 \mu$ .

Hab. in foliis vivis *Mori rubrae*, in aestivo.

For the convenience of mycologists type specimens, bearing perithecia and others bearing conidia have been deposited in the Farlow Herbarium, Harvard University, Cambridge, Mass., and in the Mycological Herbarium of the United States Department of Agriculture, Washington, D. C.

Grateful acknowledgment is made for the help and advice given by D. H. Linder, G. D. Darker and W. W. Diehl.

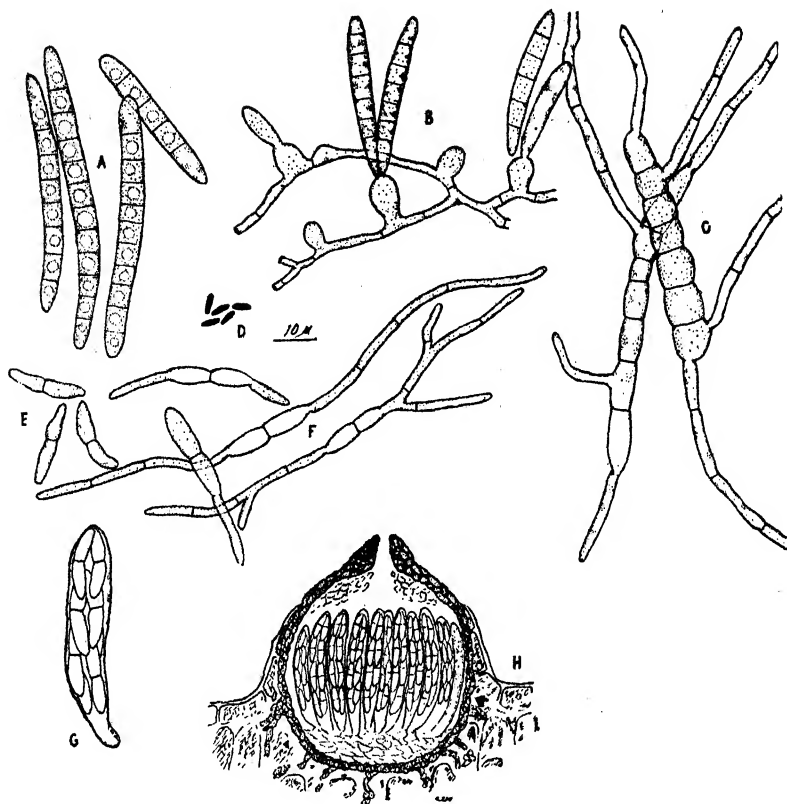


FIG. 3. A-G are drawn to the same scale, indicated near D. A, conidia of *C. arachnoidea*; B, fertile, superficial hyphae, bulbous conidiophores and conidia as shown by free-hand sections cut parallel to the leaf surface; C, germinating conidia; D, spermatia; E, ascospores of *Mycosphaerella arachnoidea*; F, germinating ascospores that were discharged on agar plates; G, mature ascus of *M. arachnoidea*; H, sketch of mature perithecium of *M. arachnoidea*.

#### SUMMARY

This report is concerned with the developmental morphology of a pleomorphic fungus that causes false mildew of mulberry. It possesses a conidial stage, that imparts to affected foliage the gross appearance of a powdery mildew and that is herein designated *Cercospora arachnoidea*. At the time of leaf abscission in autumn the lesions are occupied by spermogonia and perithecial

primordia. The perithecial stage matures in spring. The pathogen is herein described as *Mycosphaerella arachnoidea*.

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# THE DEVELOPMENT OF LYCOPERDON ACUMINATUM

DELBERT SWARTZ<sup>1</sup>

(WITH 9 FIGURES)

Our knowledge of the comparative development of species of Lycoperdaceae is gradually increasing. In addition to the review of literature given by the writer (4, 5), an additional paper on *Calvatia craniiformis* (Schw.) Fries has recently appeared (6). The following study of the development of *Lycoperdon acuminatum* is the eighth in a series of developmental studies on species of Lycoperdaceae by the writer.

## MATERIALS AND METHODS

The fruit bodies used in these studies were collected on the bark of living oak trees near Fayetteville, Arkansas, during October and November, 1934. They ordinarily occur soon after the first cool fall rains in this part of the southwestern United States. They were killed in Flemming's weaker solution and embedded in paraffin. Serial sections were cut  $7\mu$  in thickness, and stained in Heidenhain's iron-alum haematoxylin.

## OBSERVATION

*Description of the fruit body:* Fruit body at first globose, becoming ovoid to pointed egg-shaped; whitish to cream color, becoming brownish in age; usually less than 1 cm. in diameter; opening by a small apical pore. Cortex smooth, slightly wavy (rarely otherwise) (1). Sterile base absent in mature specimens. Gleba olive to pale-brown. Capillitium lacking until maturity or near maturity, simple (rarely branched), lighter than spores; usually twice as thick as the spores. Spores globose, smooth or very slightly roughened,  $3.5-4\mu$  in diameter.

<sup>1</sup> Research paper, Journal Series, University of Arkansas, No. 397.

Usually growing on bark of living trees 3–15 feet above ground.

*Rhizomorph*: The rhizomorphs are short, and, on the whole, are very poorly developed. They branch near the base of the fruit body, and these branches may penetrate the bark of the tree to a depth of 0.5–1.0 cm. There are three layers in the rhizomorph (FIG. 1); namely, (1) an outer cortex, (2) a very thin poorly developed subcortex; and, (3) a central core. The outer cortex is relatively thin, and is composed of loosely connected hyphae, which are coarse, blunt, and which stain deeply. The poorly formed sub-cortex is made up of slightly interwoven, thin-walled hyphae which are parallel to the long axis. These hyphae do not stain deeply, and are continuous with the cortex on the outside, and with the central core on the inside. The central core is not so well developed as in other species, and the component hyphae are somewhat thicker than those of the subcortex. They contain a few deeply staining, angular crystals similar to those reported in other species (2, 3, 4, 5, 6).

The rhizomorph is sometimes imbedded in a pseudoparenchymatous matrix which is also connected with the base of young fruit bodies. This rather unusual condition has not been observed in other species, and is probably a reaction to the unusual habitat.

*Formation of the fruitbody*: The fruitbody arises from the end of the very short rhizomorph as in other investigated species (4, 5, 6). It is roughly spherical at first, and the interior is undifferentiated (FIG. 2). When very young it is sparsely covered by the cortex of the rhizomorph, but with elongation and enlargement these hyphae persist only at the base. The undifferentiated interior is continuous with the central core while the outer covering is connected to the subcortex. The youngest plants have no peridia, and the periphery is made up of relatively loosely interwoven hyphae whose ends make up the outer margin of the fruit body. The outer fringe stains more deeply than the inner part of the peripheral zone. Between this more deeply staining fringe and the inner part, there is another zone of hyphae which does not stain so deeply as the tissue in the central part of the young fruit body.

*Exoperidium*: The hyphae at the apex of very young fruit bodies become radially arranged (FIG. 3); this is the initiation of the exoperidium. Gradually this radial arrangement spreads until



FIGS. 1-9. Development of *Lycoperdon acuminatum*.

the entire fruit body is covered by a relatively thin layer of such hyphae. The outer fringe is soon covered with many loosely connected, globose cells, which are very rich in protoplasm and which stain very deeply. Just beneath this peripheral layer, a layer of pseudoparenchyma is laid down (FIG. 4), and the innermost cells elongate tangentially and pass directly into the inner peridium. The exoperidium is not so thick in this species as in certain others, but it is well developed when considered in relation to the total diameter of the fruit body. The general wavy outline of the outer margin is due to the uneven thickening of this outer layer (FIG. 5).

*Endoperidium:* The differentiation of the endoperidium begins soon after the radial arrangement of the peripheral hyphae, and it is first visible in the region where the exoperidial hyphae become elongated tangentially. At first this layer is thin and indistinct, but it gradually becomes thicker, and more clearly visible. The hyphae are continuous with the exoperidium on the outside, and with the gleba on the inside. As the exoperidium gradually wears away, the smooth endoperidium is exposed. Scattered patches of pseudoparenchyma from the exoperidium may persist for some time; these areas are usually much more numerous at the base than at the apex.

*Gleba:* The primordial hyphae of the gleba are continuous with those of the central core. The region of the gleba is first visible because the hyphae are richer in protoplasm, and stain more deeply than those of the layer surrounding it. Cavities arise by mechanical splitting in this homogeneous region of rather loosely interwoven hyphae. The cavities enlarge as in other species (4), and soon become lined with a regular hymenium (FIG. 6). The first formed cavities are formed in the apical part (FIG. 5); and they gradually appear toward the basal region (FIG. 8). This cavity formation continues until the entire gleba, with the exception of a rather thick permanent layer of pseudoparenchyma just within the endoperidium (FIG. 7), is thoroughly perforated by cavities. After cavity formation has continued for some time, spores are formed. During spore formation the hyphae of the gleba are completely used up; this includes both the subhymenium and the trama which are both very poorly developed in this species. The



outlines of the cavities persist for some time due to the arrangement of the spores in their characteristic position around it. Gradually, the dry powdery spore mass escapes through the apical pore.

*Sterile base:* The youngest fruit bodies have a tissue in the basal-most part which is suggestive of a sterile base (FIG. 8). However, all of this tissue is used up during spore formation, and no remnants of it are visible in mature plants.

*Capillitium:* The capillitium is not definitely localized in the gleba in this species; instead, it is present in greatest amount in the pseudoparenchyma just inside the endoperidium (FIG. 9); and only a few scattered threads are found elsewhere. The threads are usually simple although they may branch occasionally.

*Pore formation and dehiscence:* The spores, when ripe, are gradually freed through an apical pore which is formed in the following manner. Simultaneous with the gradual wearing away of the exoperidium, the tangential hyphae at the apex of the fruit body break apart and bend outward. The layer of pseudoparenchyma just beneath this newly formed opening breaks down. In this way a continuous opening from the spore filled gleba to the outside is formed. This outward turning of these endoperidial hyphae causes the apex to have a pointed appearance. At first this pointed region is fairly rigid, but it gradually collapses during dehiscence.

#### SUMMARY

*Lycoperdon acuminatum* develops similarly to other investigated species of Lycoperdaceae. The fruit bodies arise from a poorly developed rhizomorph whose branches penetrate for some distance between the cells of the bark.

The exoperidium is formed early, and results from a radial arrangement of peripheral hyphae. It soon becomes made up of a very loose outer fringe, and a pseudoparenchymatous inner part.

The endoperidium results from a tangential rearrangement of hyphae just within the exoperidium; this is the outermost layer in completely mature fruit bodies.

The gleba is differentiated as in other species; the first cavities appear toward the apex, but gradually the entire interior including

the sterile basal part is used up. The subhymenium and the trama are very poorly formed.

The greater number of threads of capillitium are formed in the layer of permanent pseudoparenchyma just inside of the endoperidium; relatively few threads are scattered through the gleba.

A comparison of these developmental characters with those of other species which have been studied indicate that it is most closely related to *Lycoperdon Wrightii*.

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# SPERMATIA AND NUCLEAR MIGRATIONS IN PLEURAGE ANSERINA

B. O. DODGE

(WITH 2 FIGURES)

The formation of microspores by certain ascomycetes has long been known. Their function in fertilization was for many years taken for granted, although this was not actually proved for any species until very recently. A study of the many different ways in which fertilization is accomplished in ascomycetes has served to raise questions regarding the importance or the necessity for spermatia. Certainly for the heterothallic species they are well adapted to insure cross-fertilization with opportunities for hybridization and the development of new races. The modern tendency, however, for those who discover spermatia of an ascomycete for the first time is to magnify their importance and to insist on their necessity, ignoring all the other ways these same fungi have of insuring cross-fertilization. Few persons who have studied species of *Neurospora* even intensively have ever seen their spermatia. In many species of ascomycetes spermatia are not developed at all, while in others they are only occasionally found. Races of *Gelasinospora tetrasperma* which have spermatia may yet be found. We should know in every case how spermatia originate and how they function both sexually and asexually if we are to understand the interrelations of species in the scheme of their evolution.

Judging from the morphology of their ascocarps, species of *Neurospora* must be closely related to the Sordariaceae. Further evidence for such a relationship is found in the similarity in the spermatial apparatus of *Neurospora* and *Pleurage*. In *Neurospora* (Dodge, 1932) spermatia are usually borne on specialized branches (l. c. fig. 1) each of whose cells may be called a spermogonium. The spermatia are probably not actually organized as

endoconidia yet they present the appearance of being squeezed out through the characteristic collar-like or inverted bell-shaped opening of which there is only one for each cell or spermogonium. The spermatia may adhere in short chains and later gather together in great numbers in droplets of water. Spermogonia may also arise more or less singly from surface hyphae as noted in the paper referred to.

A paper by Satina (1917) on the development of species of the Sordariaceae contains some very interesting information which has not been noted in subsequent discussions on nuclear behavior and spermatia in the ascomycetes. Under *Podospora curvula* she says, "The conidia with one nucleus develop in enormous quantities in short swollen cells, which appear on hyphae on side branches (fig. 17). One could not succeed in germinating the conidia." Persons familiar with spermatia of *Neurospora* and other ascomycetes will understand that Satina had what we call microconidia or spermatia under observation. Although her figure 17 is rather sketchy there is the suggestion of a flaring bell-shaped collar at the opening of the spermogonium. Discussing *Podospora* (*Pleurance*) *anserina* Satina says: "All above stated of *P. curvula* can be fully attributed to *P. anserina*." There can be no doubt that this statement was intended to cover what had been said about the "conidia" (spermatia). In a personal communication Dr. Satina says that she saw spermatia of *P. anserina* and that they looked much like those of *P. curvula*. She had made a number of drawings of them for that paper, but owing to the unfavorable conditions for publication in Russia at that time she was obliged to eliminate them. Satina was likewise the first to confirm Wolf's statement (1912) that each of the four spores in an ascus contains two nuclei. Dowding (1931) has further confirmed Wolf on this point.

Through the kindness of Dr. E. Silver Dowding (Mrs. Keeping) and Dr. R. F. Cain, I was able to obtain cultures of *Pleurance taenioides* and *P. anserina* for this preliminary study. Since all species of *Neurospora* studied show a fourth simultaneous nuclear division which occurs after the ascospores are delimited it was of interest to follow this point through the later stages in *Pleurance taenioides* and *P. anserina*. My preparations show regularly only

two nuclei in normal spores of both species. The spore wall thickens rather rapidly so that one cannot be certain from these preparations whether there is a subsequent division of the nuclei. Probably there is not, at least not until germination begins.

*Pleurage taenioides* can be made to fruit in culture on corn meal agar where spermatia are usually produced rather sparingly. They will be described at another time when other genetic experiments will be reported. In this species many asci have only two large spores. Here one sees four nuclei, often in a row, along the center of the spore.

The spermatial apparatus of *P. anserina* proves to be quite unlike that described by Ames (1934) for this species. My material had been carefully identified by Dr. Cain, an authority on this group, and it has also been checked up by the writer. The tufts of stiff hairs or bristles that develop on one side of the perithecial neck is rather characteristic when the fruit bodies are developed on the surface of the medium. It was noticed in some plate cultures, which happened not to have been disturbed, that the tufts on the perithecia had all been developed on the same side with respect to the light exposure. Perithecia which develop below the surface of the agar do not seem to have these tufts. There are other features regarding their development which are interesting, but which require further study.

The writer had considerable trouble in finding asci with five spores although small ascospores are occasionally developed. The percentage of ascospore germination is also very low. It was much easier to obtain unisexual races by isolating single hyphal-tips. On corn meal agar perithecia begin to develop on the fourth or fifth day if the culture originated from a single normal ascospore, whereas if one mates two unisexual races it usually requires much longer.

Originally about 40 single ascospore races were obtained from the culture received from Dr. Cain. When these races were grown on potato-dextrose and dextrose media their mycelia were all very dark colored, but certain races like no. 7 grown on corn meal agar were mottled and somewhat lighter in color (FIG. 1). None of these races produced spermatia at first. When, however, certain unisexual races were grown in plate cultures on corn meal

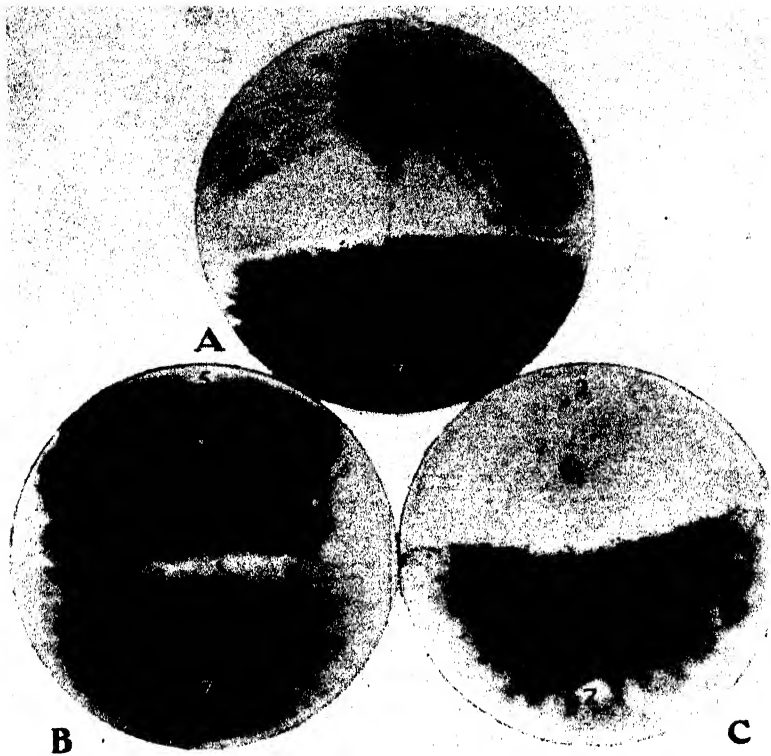


FIG. 1. *Pleurage anserina*. A, plate culture of races 14 and 7. Race 14 produces many spermatia, the light colored sectors without spermatia; race 7 does not usually produce spermatia. On dextrose agar the mycelium of this race is very dark, but on corn meal agar it is mottled as shown in B and C. B, mating of race no. 5 with race 7, no spermatia formed by either race in this culture; fertilization due to nuclear migrations from mycelium 7 into 5. C, colorless race no. 2 mated with 7. The first perithecia formed along the line of meeting could have been due to natural spermatization but the other perithecia distributed over mycelium 7 must have been due to nuclear migration, as no spermatia could be found on the area covered by race 7 and there was no indication of an overgrowth of mycelium from race 2.

agar, sectoring occurred. The sectors gave colorless mycelia which produced quantities of spermatia. Our races 5 (FIG. 1, B), 9, and 19, for example, have been transferred many times to various kinds of agar, but as yet they have not produced spermatia. Spermatia would no doubt form if the races could be made to sector.

Spermatia are usually developed on specialized aerial branches as shown in figure 2, A-C. Each cell is potentially a spermogonium just as is the case with *Neurospora*. The flaring inverted bell-shaped aperture for spermatial discharge is usually much longer and more prominent than it is in *Neurospora*. The masses of spermatia are somewhat brownish in color, especially where the spermatial apparatus is composed of olivaceous cells.

Spermogonia are sometimes formed singly along the sides of specialized or thickened hyphae. They are then more or less barrel-shaped (FIG. 2, D, G) as figured by Satina. In general, however, spermatia are borne on a rather characteristically branched spermatophore system as shown in the figure 2, A-C.

Some cultures such as no. 14, shown in figure 1, are colorless but appear light brownish where great masses of spermatia are formed. Such mycelia may sector to produce fewer spermatia, or a non-spermatial dark-colored race may sector to produce a colorless mycelium upon which spermatia will be formed abundantly. This process is peculiarly reversible in that a colorless race may revert in part or spots so that the surface hyphae become thick-walled and dark olivaceous to blackish. Such dark hyphae will also develop spermogonia (FIG. 2, F, G).

Spermatia are formed on the surface of the medium, yet one finds perithecia with asci deep down in the agar in tube cultures where direct spermatization would be out of the question. Furthermore, perithecia mature in plate cultures where two races which are opposite in their sex-reaction are mated and where neither race produces spermatia. There is no question that fertilization is frequently brought about through nuclear migrations just as it is in comparable matings of *Neurospora tetrasperma* and *Gelasinospora tetrasperma* (Dodge, 1935). This can be readily proved by isolating single fragments of hyphae as described in the paper

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FIG. 2. *Pleurage anserina*. A-C, characteristic spermogonial branches, each cell of which is a spermogonium; the characteristic flaring apex is best shown in C1; D, F, G, show spermogonia developing directly from cells of specially differentiated horizontal hyphae, which in these cases were darkly colored olivaceous; E, characteristic spermatia; H, I, enlarged views of spermogonia showing particularly well the inverted bell-shaped tips suggesting a *Phialophora*. (Various magnifications.)



FIG. 2.



referred to. Such fragments are proved totipotent or bisexual when mycelia from them mature perithecia. If there were merely an intermingling of two unisexual mycelia, isolated fragments must always be unisexual. The idea that a mycelium derived from a normal spore containing both kinds of nuclei as to their sex reaction must split up into its two unisexual components so that spermatia from one branch can spermatize trichogynes from some other branch and vice versa has not been supported by any evidence, although that very thing no doubt does occasionally occur in cultures of our facultatively heterothallic species. The point here is that while spermatia of *Neurospora tetrasperma* and *Pleuraea anserina* are at times advantageous in fertilization, they are altogether dispensable just as they must be in *Gelasinospora tetrasperma* where spermatia are unknown.

Figure 1, C shows a mating of race No. 2 with race No. 7. Race 2 is colorless and produces spermatia rather sparingly. Race 7 seldom produces spermatia, and none could be found on its mycelium in this particular culture. Nevertheless, after about ten days perithecia began to form along the line of meeting of the two mycelia and then others appeared down along the lines of growth of the no. 7 hyphae. The fruit bodies do not show well in this figure because most of them were developed deep down in the agar. Following the method fully described (**Dodge, 1935**) a set of 1-tip isolations was made from each of five different matings. The transplant of course was taken from a region showing perithecia. That nuclear migration in *Pleuraea anserina* is much slower and the resulting heterokaryosis or diploidization is less complete than it is in similar cultures of the facultatively heterothallic species of *Neurospora* and *Gelasinospora* is proved by the results obtained.

In the first test where races 6 and 7 were mated, five 1-tip isolates were proved to be bisexual while twenty-five remained unisexual in their reactions. In a second trial from another culture of the same mating, twenty-one isolates gave perithecia and twelve were proved to be unisexual and so remained sterile. In a mating of races 7 and 8, only one isolate gave perithecia while fifteen were unisexual. Nineteen 1-tip isolates were made from a 7  $\times$  9 mating and only two isolates gave perithecia. When a transplant was

taken from one of these two cultures and thirty-eight 1-tip isolates were obtained heterokaryosis was found to have become well established, thirty-four isolates giving perithecia and only four were proved to be unisexual.

Certain breeding experiments involving crosses between various races of *Pleurage anserina* have shown that this species is bound to prove highly interesting. Those who undertake this work with fixed notions as to the way things are going to work out, will be disappointed. One would naturally expect to find the nuclear spindles of *Pleurage anserina* to be so oriented as to insure the inclusion of two nuclei of opposite sex-reaction in each spore as they are in *Neurospora tetrasperma*. Satina (1917) however, seems to think that the two nuclei included in a spore are sisters. There certainly is great need for further cytologic as well as genetic work with this species.

THE NEW YORK BOTANICAL GARDEN

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# A HEART ROT OF MAGNOLIA CAUSED BY FOMES GEOTROPUS

H. W. JOHNSON<sup>1</sup> AND C. W. EDGERTON<sup>2</sup>

(WITH 1 FIGURE)

## INTRODUCTION

One of the most beautiful shade trees of southern Louisiana, and a valuable timber tree as well, is the great-flowered magnolia, *Magnolia grandiflora* L. Many old trees of this species are growing on the Louisiana State University campus at Baton Rouge though the number has gradually decreased in recent years due to the attack of a heart-rotting fungus which lowers the vitality of the trees and weakens the trunks to such an extent that the trees are finally unable to withstand the strain of storms. Old trees seriously affected with this disease can be told at a considerable distance. The foliage in the top portion of such a tree is sparse and often some of the upper branches are dead or dying. In general the trees have a "staghead" appearance which is quite noticeable. In recent years attempts have been made from time to time to save some of the trees by tree surgery by cleaning out a portion of the rotted heart-wood and filling the cavities with cement. As would be expected with such a disease, no beneficial effects of the treatment have been noticed.

For several years a pore fungus has been observed fruiting at the base of many of the affected magnolias on the campus. The fruiting bodies (FIG. A) usually develop in recesses formed where the main roots join the trunk and hence are frequently abnormal in form. Typical bracket forms, however, have been found on the inside of a hollow magnolia stump and also on the inside of

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hollow trees and the fungus has been identified as *Fomes geotropus* Cooke.

The fruiting bodies used in making this identification were sent to L. O. Overholts of Pennsylvania State College who verified the determination and wrote that these were the largest fruiting bodies of *F. geotropus* he had ever seen and that magnolia was a new host record for this fungus. The fungus appears to be a wound parasite and possibly basal fire burns or other injuries have been responsible for exposing the heartwood to attack. Apparently this heart rot of magnolia has not previously been described.

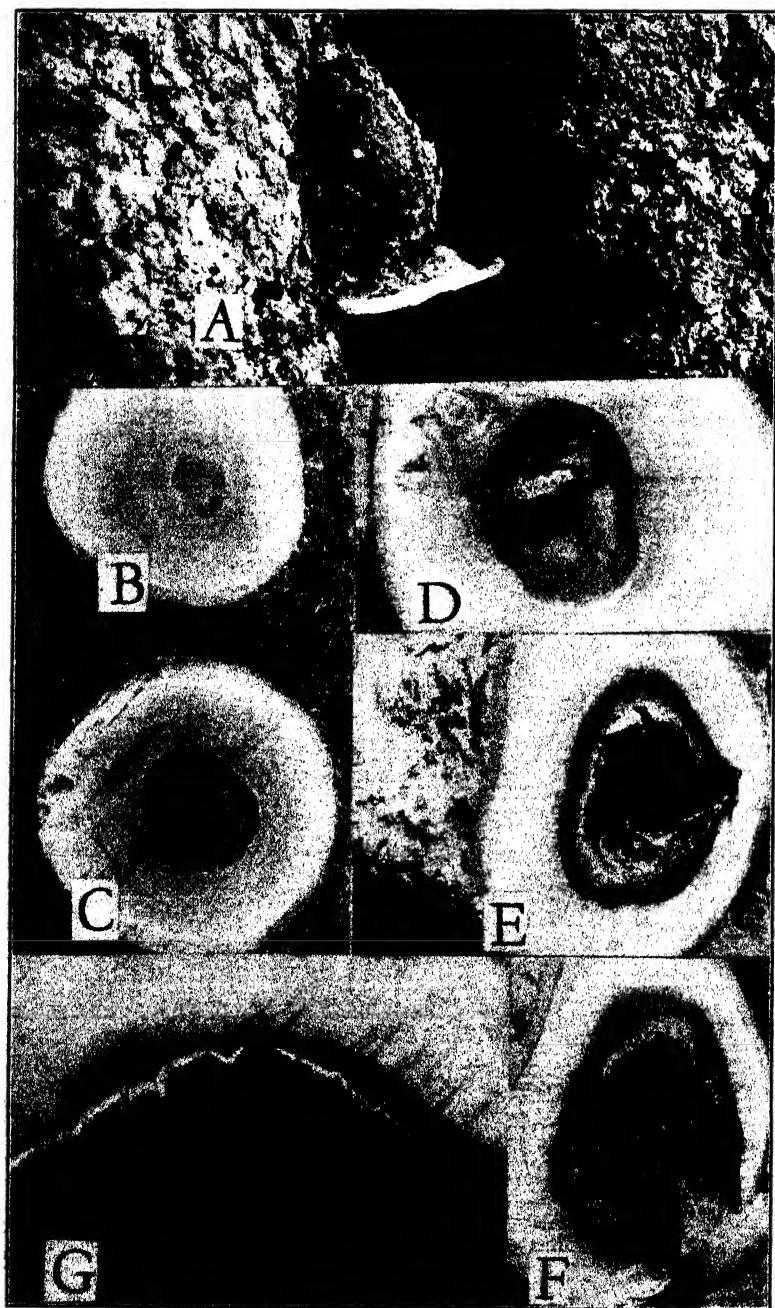
#### DESCRIPTION OF HEART ROT

The following description is based upon a detailed examination of a large magnolia much weakened by heart rot which fell in December, 1929, while heavily loaded with ice following a sleet storm.

The storm was one of the most severe on record. Ice about a half inch thick covered all the leaves and branches. It seemed of interest to determine the amount of ice being held up by one of these trees. The ice on a number of leaves was weighed and it was found that there was an average per leaf of about 90 grams. Counting 30,000 leaves to the tree, this gave a total weight on the leaves of about three tons. Including the ice upon the twigs and branches, it seems quite probable that the total ice load per tree weighed between three and a half and four tons. It is not surprising that a tree severely weakened by a heart rot should fall under such a strain.

The trunk of the fallen tree was cut into logs and thin cross sections were sawed off at various heights and taken into the laboratory for study. The amount of rot at various points in the trunk is shown by the pictures of these cross sections (FIG. B-F).

In magnolia the typical mature rot is brown in color. In its incipient stage, the rot is grayish-black with distinct greenish and reddish tinges when freshly cut surfaces are exposed to the air. The normal magnolia heartwood is creamy white. Black zone lines are conspicuous near the advancing edge of the rotted area. Figure G shows these zone lines and the fungous mycelium which grew from the rotted wood just behind them when the cross sec-



tions of the trunk were taken into the laboratory and kept for several days in a rather humid place.

Termites and other wood-boring insects were found abundantly in the rotted heartwood and appeared to be playing a part in the final reduction of the wood to a soft, brown, crumbling mass which gradually fell out, leaving a central cavity. In the tree studied, this cavity tapered upward from a diameter of 36 inches at the base to a slit-like hollow approximately 4 inches long and 1 inch wide at a height of 20 feet above the ground. The rot had broken out on one side of the trunk and the cavity was open to a height of 14 feet. The opening tapered from 24 inches in width at the base to 8 inches in width at a height of 13 feet and then closed rather abruptly.

From the point slightly above 20 feet where the central cavity ended, the rotted area surrounded a shake in the heartwood which extended to a height between 38 and 40 feet. The rot surrounding the shake was all in the incipient stage (grayish-black color). Distinct zone lines darker in color were found at the edge of the rotted area in this portion of the trunk as well as in the region of mature rot nearer the base of the tree.

#### SUMMARY

A heart rot of *Magnolia grandiflora* L. which appears to be responsible for the destruction of many of the old trees of this species in southern Louisiana is described.

A pore fungus, *Fomes geotropus* Cooke, has been found constantly associated with the heart rot and is evidently its cause.

Apparently this is the first record of this fungus attacking *Magnolia grandiflora*.

DEPARTMENT OF BOTANY,  
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BATON ROUGE, LOUISIANA

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FIG. 1. A, *Fomes geotropus* growing at base of trunk of *Magnolia grandiflora*; B-F, sections of log of *Magnolia grandiflora* affected with heart rot: B at 23 feet, C at 20 feet, D at 18 feet, E at 15 feet, and F at 10 feet from basal end; G, mycelium of *Fomes geotropus* growing out of rotted area in heart wood of *Magnolia grandiflora* after section of log was cut and kept moist for several days.

## NOTES AND BRIEF ARTICLES

### CHRONICA BOTANICA

There are nearly 4,000 Institutions of pure and applied botany. There are between 60,000 and 70,000 botanists. There are about 1,000 periodicals concerned with botany! How can you keep in touch with all this activity? How can you find out what other botanists are doing and what new work they are planning. *CHRONICA BOTANICA* will help you. Subscribe to it and help with the compilation of the next volume.



All directors of institutions and secretaries of societies will receive a copy of our questionnaire at the beginning of December of each year. Replies should reach the Editor-in-Chief, Dr. F. Verdoorn, Leiden, Holland, not later than January 30th, as it will generally be impossible to make use of information received after that date. Directors or Secretaries, who do not receive our preliminary circular, which will reach them annually before Oct. 15th, are kindly requested to acquaint us of the fact at their earliest convenience, which will enable us to include them in our mailing list, and will ensure their receiving a copy of the questionnaire in December.

Prospectus, sample pages and further information may be had from the EDITORIAL AND PUBLISHING OFFICE, P. O. Box 8, Leiden, Holland.

### ILLUSTRATIONS OF MYXOMYCETES

Under the title "Myxomycetes of Nasu District" Dr. H. Hatori has just issued one of the most attractive volumes on the slime

molds that has ever been published. The text is in Japanese, but in addition to the reproduction of several figures by other authors there are 306 original photographs, illustrating habit and microscopic characters of the 124 species listed, and thirty-three colored plates, one after a water color by Miss Lister, the others evidently original, containing in all 128 figures. In accuracy and beauty the colored illustrations rival those of Miss Lister and Mr. Crowder, and constitute a contribution of permanent value to the iconography of the group.—G. W. MARTIN.

A. J. Mix, Department of Botany, University of Kansas, wishes to obtain freshly collected material of *Taphrina* (including *Exoascus* and *Magnusiella*). In return he will be willing to undertake special collection of fungi locally available. Special interests include: *Taphrina cocrulescens* on all possible species of oaks, plum pockets on wild and cultivated plums, and any species of *Taphrina* on ferns. Specimens should be collected in ascus-bearing condition, pressed for 24 hours and then mailed.

#### SUMMER FORAY

The Summer Foray will be held at the Mountain Lake Biological Laboratory, Mountain Lake, Va., **Sept. 3–5th**. You are asked to bring your blankets, sheets, and towels if you intend to make headquarters at the Laboratory. The rates are \$2.00 per day. The nearest hotel is 2 miles away and somewhat expensive, while more reasonable accommodations may be found in Blacksburg, 20 miles away. It is hoped that as many as possible will stay at the Laboratory.





# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVIII JULY-AUGUST, 1936

No. 4

## SOME NEW COLORADO DISCOMYCETES

EDITH K. CASH

(WITH 6 FIGURES)

During the summers of 1929, 1930, 1933, and 1935, Mr. Ross W. Davidson made numerous collections of discomycetes in the Grand Mesa National Forest, Colorado. Two previous papers (1, 2) have dealt with several species of *Sclerotinia* and a few of the Cenangiaceae from this locality: various other collections made by Mr. Davidson during these trips are discussed here. The specimens are deposited in the Mycological Collections of the Bureau of Plant Industry, and duplicates of those here listed as numbers 1, 2, 3, 4, and 6 are also in the Farlow Herbarium of Harvard University, the Herbarium of the New York Botanical Garden, and the Herbarium of the University of Michigan.

### 1. *PROPOLIS FAGINEA* (Schrad.) Karst. var. *atra*, var. nov.

Apothecia immersed in whitened areas of the wood, irregularly elliptical, occasionally circular, sometimes confluent, surrounded by the lacerated epidermis, brownish olive<sup>1</sup> to deep olive, greenish slate-black when dry,  $1-3 \times .7-1$  mm.; asci cylindrical to cylindrical-clavate, 8-spored,  $145-175 \times 11-12 \mu$ ; spores uniseriate, rarely biseriate above, elongate-cylindrical, hyaline, straight or slightly curved, unicellular, biguttulate, thick-walled, granulose,  $22-28 \times 8-10 \mu$ ; paraphyses filiform, thickly branched and yel-

<sup>1</sup> Color terminology follows Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912.

lowish at the tips, forming a dense brownish or greenish mazaedium.

Ascomatibus immersis, ellipticalibus orbicularibusve, viridiatris,  $1-3 \times .7-1$  mm.; ascis cylindricis vel cylindrico-clavatis,  $145-175 \times 11-12 \mu$ ; sporis plerumque uniseriatis, rare biseriatis, elongato-cylindricis, hyalinis, unicellularibus, granulosis,  $22-28 \times 8-10 \mu$ ; paraphysibus filiformibus, dense ramosis et luteis, mazaedium viridifusum formantibus. Hymenio viridi-atro et ascis longioribus et angustioribus a speciei differt.

On old weathered wood of *Populus tremuloides*, Mesa Lakes, June 13, 1930, R. W. D. 222 (type), June 18, 1930, 324-a, June 26, 1930, 455-a, and July 18, 1930, 731.

The color of the hymenium would not in itself constitute a character of sufficient importance for separating this as a variety of *Propolis faginea*, since although generally white or whitish, various other colors are noted by Rehm (5, p. 149-150): reddish, yellowish, brownish, etc. The much longer asci, however, are distinctive. *Propolis Betulae* Fuckel, which is included by Rehm as a variety of *P. faginea*, is described as having asci up to  $162 \mu$  in length, but in this species the spores are also much longer,  $34-36 \mu$ .

## 2. *Cenangella oricostata*, sp. nov. (FIG. 4).

Apothecia coriaceous, subglobose, sessile, depressed and radiately ridged at the apex, collapsing when old, emerging sometimes singly, more often in groups from cracks in the bark on a thin sclerotic layer, dark grayish olive, drying olivaceous black, 1-2 mm. diam., 1-1.5 mm. high, slightly furfuraceous; hymenium pallid neutral gray; asci cylindrical, short-pedicellate, 8-spored,  $100-130 \times 6-8 \mu$ , wall  $2.5 \mu$  thick at the narrowed apex; spores fusoid-clavate, straight, 1-2-seriate, hyaline, uniseptate near the center, not constricted, upper cell broader and more rounded, lower narrower and acute,  $12-15 \times 3-4 \mu$ ; paraphyses hyaline, filamentous, not septate, longer than the asci, with two to three often recurved and slightly inflated branches at the tip; hypothecium prosenchymatous, pale brown; inner layer of the exciple thick, dark brown, of dense, thick-walled pseudoparenchyma; outer layer of olivaceous hyphae which break up in loose clumps scattered over the surface and become thickened into ridges radiating from the apex.

Apotheciis coriaceis, subglobosis, sessilibus, apice depressis et radiatocostatis, erumpentibus, griseo-olivaceis vel atro-olivaceis, 1-2 mm. diam., 1-1.5 mm. altis; hymenio pallide griseo; ascis cylindraceutis, breve pedicel-

latis,  $100-130 \times 6-8 \mu$ ; sporis fusoido-clavatis, 1-2-seriatis, hyalinis, 1-septatis,  $12-15 \times 3-4 \mu$ ; paraphysibus hyalinis, filamentosis, ramosis, apice leniter inflatis et recurvatis; excipulo atro-brunneo, crasso, filamentis olivaceis tecto.

On twigs of *Ribes Wolfii*, Mesa Lakes, June 16, 1935, R. W. D. 778.

The fungus is apparently a member of the Cenangiaceae, superficially very similar to *Godronia*. Since the only genus in this family with two-celled spores is *Cenangella* Sacc., it is placed here, although *Cenangella* is not recognized by some recent authors. Von Höhnelt (3, p. 369) considered *Cenangella*, as typified by *C. Fraxini*, synonymous with *Dermatella* Karst., while Nannfeldt (4, p. 82) includes both of these genera as synonyms of *Dermatea* Fries. It seems probable from the descriptions that various species of *Cenangella* should more properly be assigned to *Dermatea*, but the Colorado fungus differs widely from that genus in its unbranched, hyaline paraphyses and fusoid-clavate spores.

Although the asci and spores seem to be mature, no open apothecia were found in this collection. The fruiting-bodies may have a small round mouth like some species of *Godronia*, or more probably split into stellate lobes along the radiating ridges at the apex. These ridges suggest those in *Godroniopsis quercea* (Schw.) Diehl & Cash, but in *Cenangella oricostata* they are confined to the apical region and are much less pronounced.

Emerging from the cracks in the bark on the same basal stroma with the apothecia of the discomycete is a pycnidial fungus. The subglobose, non-ostiolate pustules, .7-1 mm. in diameter, and of the same color and texture as the apothecia, are completely filled with closely packed, bacillar, hyaline conidia,  $2-4 \times 1-1.5 \mu$ . No conidiophores were observed.

Mr. Davidson has suggested that *C. oricostata* may be parasitic during early stages of development, since he found it fruiting either on dead areas of living stems or on dead twigs attached to living stems.

### 3. *Tapesia Lonicerae*, sp. nov. (FIG. 1).

Apothecia sessile, superficial, gregarious, soft-fleshy, 1-2.5 mm. diam., patelliform, irregularly contorted when dry, margin crenu-

late, inrolled, exterior black, raisin black or dark livid purple, densely setose at the margin, hairs bone brown or more rarely Diamine brown; hymenium pale neutral gray; asci cylindrical, narrowed at the apex, short-stipitate, 8-spored,  $65-75 \times 7-9 \mu$ ; spores obliquely uniseriate or biseriate, fusoid-clavate, uniseptate, not constricted, hyaline,  $12-13.5 \times 2-2.5 \mu$ ; paraphyses filiform, hyaline, non-septate, simple or branched near the base, the slightly inflated tips extending above the asci; hypothecium a loose prosenchymatic layer  $50-100 \mu$ ; cortical layer pseudoparenchymatic, made up of dark, subglobose cells  $5-8 \mu$  in diameter; hairs brown, smooth, septate,  $140-170 \times 2.5-3 \mu$ .

Apotheciis sessilibus, superficialibus, molle carneis, atris, patelliformibus, margine crenulato et setoso,  $1-2.5 \mu$  diam.; hymenio griseo; ascis cylindricis, apice attenuatis, octosporis,  $65-75 \times 7-9 \mu$ ; sporis oblique uniseriatis vel biseriatis, fusoido-clavatis, uniseptatis, hyalinis,  $12-13.5 \times 2-2.5 \mu$ ; paraphysibus filiformibus, hyalinis, septatis, leniter inflatis; hypothecio prosenchymatico,  $50-100 \mu$  crasso; cortice pseudoparenchymatico; pilis brunneis, glabris, septatis,  $140-170 \times 2.5-3 \mu$ .

On twigs of *Lonicera involucrata*, Mesa Lakes, June 16, 1935, R. W. D. 779.

Both Rehm and Saccardo limit *Tapesia* to species of the Mollisiaceae having a subicle and 1-celled spores. Nannfeldt (4, p. 99), however, includes species with two-celled spores in the genus, so that according to his interpretation this fungus on *Lonicera* may be considered a *Tapesia*. Moreover, it does not readily fall in any of the genera of the family described with two-celled spores. *Niptera* has a smooth exciple, *Psorotheciopsis* biscuit-shaped spores, while the species of *Linhartia* are foliicolous, brightly colored fungi with paraphyses forming a mazaedium.

According to Mr. Davidson's records this species was abundant on *Lonicera involucrata* in the summer of 1935 soon after the melting of the snow. It appeared to be saprophytic on the outer bark at the base of living stems.

#### 4. *Tapesia ribicola*, sp. nov. (FIG. 3).

Apothecia sessile, superficial, depressed-globose, then disc-shaped, irregularly contorted when dry, often hysteroïd or triangular, gregarious, soft-fleshy, .6-1.5 mm. diam., exterior fus-cous-black to black and smooth near the base, drab-gray to white and fimbriate at the margin; hymenium Court gray to Puritan gray; asci cylindrical-clavate, short stipitate, narrowed at the apex,

8-spored,  $37.5\text{--}50 \times 4.5\text{--}5 \mu$ ; spores biseriate, elongate-ellipsoid to clavate, hyaline, unicellular, straight or slightly curved,  $7\text{--}11 \times 1.5\text{--}2 \mu$ ; paraphyses filiform, hyaline, septate, unbranched, longer than the asci, not inflated; exciple pseudoparenchymatic, of small, dark, thick-walled, subglobose or hexagonal cells  $5\text{--}7 \mu$  in diam., densely covered toward the margin by brown, septate hyphae  $2.5 \mu$  diam., subhyaline at the tips.

Apotheciis gregariis, sessilibus, superficialibus, subglobosis demum patellatis, carneis-membranaceis, .6–1.5 mm. diam., base fusco-nigris, glabris, margine albo-griseis, fimbriatis; hymenio griseo; ascis cylindrico-clavatis, breviter pedicellatis, apice angustatis, octosporis,  $37.5\text{--}50 \times 4.5\text{--}5 \mu$ ; sporis biseriatas, clavatis, hyalinis, unicellularibus,  $7\text{--}11 \times 1.5\text{--}2 \mu$ ; paraphysibus filiformibus, hyalinis, septatis; textura excipuli pseudoparenchymatica, marginem versus hyphis pallide brunneis,  $2.5 \mu$  diam., obsitis.

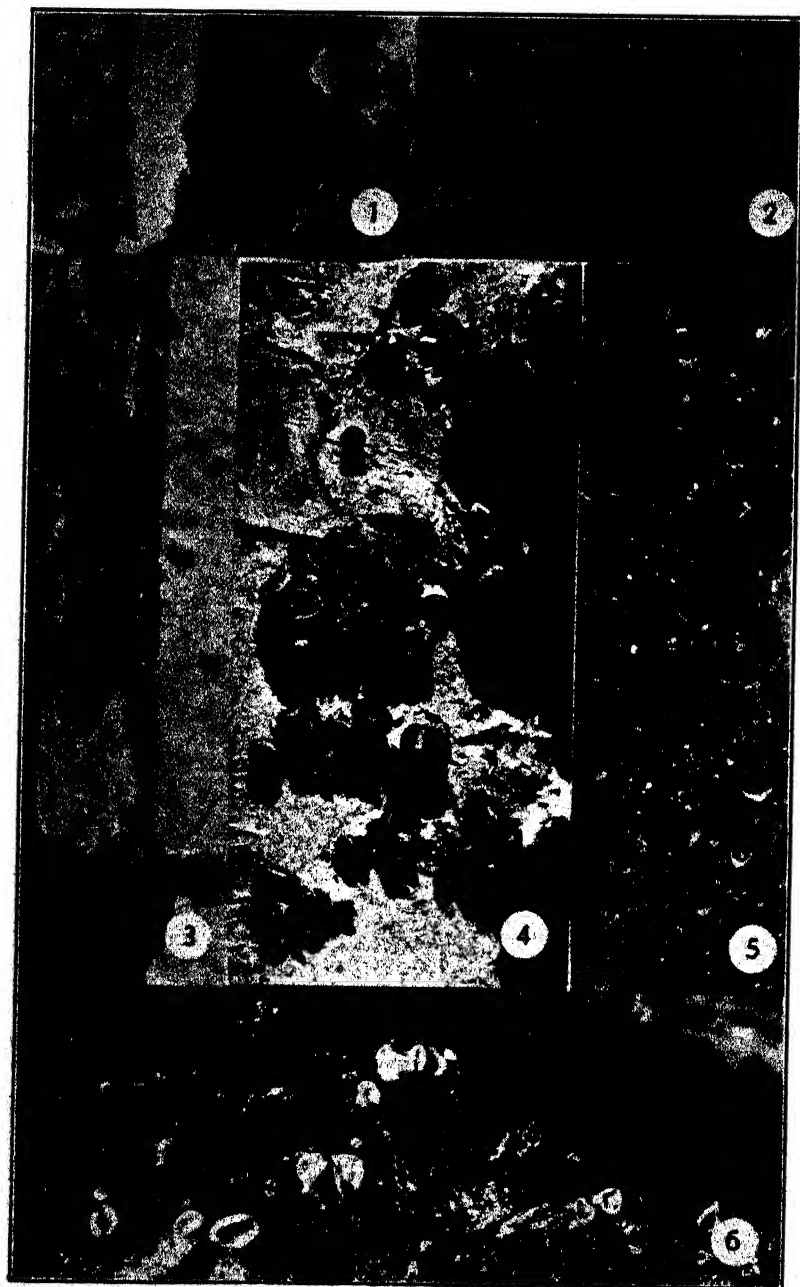
On twigs of *Ribes montigenum*, Mesa Lakes, June 15, 1935, R. W. D. 780 (type); on *Ribes* sp., Land's End, June 11, 1935, 775 and Buzzard Creek, June 17, 1935, 783.

The spores of *Mollisia ribesia* Cooke & Peck and *Pyrenopeziza rimicola* (Karst.) Sacc., both of which occur on *Ribes*, are only  $4\text{--}5 \mu$  long. Among the species of *Tapesia* described, the most similar are *T. melaleucoides* Rehm and *T. coloradensis* Ellis & Ev., from which *T. ribicola* differs in the broader spores.

#### 5. *Pezizella aurantiaca*, sp. nov. (FIG. 6).

Apothecia sessile, superficial, single or cespitose, at first subglobose, then cupulate to applanate, contorted by mutual pressure, waxy-fleshy, salmon-orange to orange-rufous, 1–2 mm. diam., pulverulent, hymenium concolorous; margin thin, delicately fimbriate, paler yellow, inrolled when dry; asci cylindrical-clavate, gradually narrowed at the base, wall thickened at the apex, 8-spored,  $38\text{--}45 \times 4\text{--}5 \mu$ ; spores cylindrical, straight or curved, 1–2-seriate, hyaline or pale greenish, unicellular with one oil drop in each end,  $7\text{--}9 \times 1.5\text{--}2 \mu$ ; paraphyses flexuous, septate, rarely branched near the base, gradually enlarged at the tip to  $1.5 \mu$ ; exciple prosenchymatous, composed of pale reddish hyphae, the loose ends of which form the fimbriate margin.

Apotheciis sessilibus, singulis vel caespitosis, cupulatis applanatisve, ceraceis, aurantio-rubris, 1–2 mm. diam., minute luteo-pulverulentis, margine tenue, leniter fimbriato; ascis cylindraceo-clavatis, octosporis,  $38\text{--}45 \times 4\text{--}5 \mu$ ; ascosporis cylindricis, 1–2-seriatis, hyalinis vel subhyalinis, unicellularibus, biguttulatis,  $7\text{--}9 \times 1.5\text{--}2 \mu$ ; paraphysibus flexuosis, apice usque  $1.5 \mu$  latis.



FIGS. 1-6.

On bark of *Picea* sp., Grand Mesa, July 2, 1929, R. W. D. 132 (type), and July 21, 1929, 143.

In general appearance this discomycete resembles *Pseudohelotium laricinum* Ellis & Ev., from which it differs microscopically. Kauffman's *Helotium sulphuratum* var. *Piceae*, which occurs on needles of *Picea Engelmanni* in Colorado, also has larger asci and spores.

#### 6. *Belonium aggregatum*, sp. nov. (FIG. 5).

Apothecia sessile, urceolate to patellate, soft-fleshy, densely crowded on a more or less evident subiculum of pale olivaceous hyphae  $3-4\ \mu$  diam., fuscous-black to olivaceous black, hymenium concolorous, margin paler and fimbriate, entire fungus black when dry; asci cylindrical-clavate, slightly narrowed at the apex, pore blue with iodine, 8-spored,  $50-65 \times 6-7\ \mu$ ; spores 1-2-seriate, clavate to cylindrical, 1-3-septate, not constricted,  $13-15 \times 2.5-3\ \mu$ ; paraphyses filiform, unbranched, septate, hyaline, slightly enlarged at the apex to  $2\ \mu$ ; exciple prosenchymatic, of thick-walled, olivaceous hyphae which become subhyaline and fasciculate at the margin.

Apotheciis sessilibus, urceolatis dein patellaribus, carnosulis, in subiculo hypharum olivacearum,  $3-4\ \mu$  diam. dense aggregatis, fuscis vel olivaceo-atris, hymenio concolore, margine pallidioris fimbriato; ascis cylindrico-clavatis, apice attenuatis,  $50-65 \times 6-7\ \mu$ ; sporis hyalinis, 1-2-seriatis, clavatis vel cylindricis, 1-3-septatis,  $13-15 \times 2.5-3\ \mu$ ; paraphysibus filiformibus, simplicibus, septatis, hyalinis, apice  $2\ \mu$  diam.; textura excipuli prosenchymatica, olivacea.

On decorticated wood of *Populus tremuloides*, Mesa Lakes, July 18, 1930, R. W. D. 734-a (type), and June 18, 1930, 341; on weathered wood of *Salix*, June 14, 1930, 240-a.

The dark subicle is sometimes nearly absent; when present it gives the fungus the appearance of a *Trichobelonium*, from which it differs in the shorter spores and prosenchymatous texture of the exciple.

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FIGS. 1-6. 1, *Tapesia Lonicerae* on *Lonicera involucrata*, R. W. D. 779,  $\times 5$ ; 2, *Belonium inconspicuum* on *Abies* sp., R. W. D. 500-a,  $\times 5$ ; 3, *Tapesia ribicola* on *Ribes montigenum*, R. W. D. 780,  $\times 5$ ; 4, *Cenangella oricostata* on *Ribes Wolfii*, R. W. D. 778,  $\times 5$ ; 5, *Belonium aggregatum* on *Populus tremuloides*, R. W. D. 734-a,  $\times 10$ ; 6, *Pezizella aurantiaca* on *Picea* sp., R. W. D. 132,  $\times 5$ . Photographic negatives by M. L. F. Foubert.



**7. *Belonium inconspicuum*, sp. nov. (FIG. 2).**

Apothecia sessile, superficial, single, smooth, patellate, thin-membranous, .2-.5 mm., fuscous-black, hymenium drab; asci clavate, short-pedicellate, wall thickened at the apex, pore blue with iodine,  $50-65 \times 8-10 \mu$ , averaging  $50 \times 7 \mu$ , 8-spored; spores ellipsoid to broad-clavate, obliquely 1-seriate to irregularly biseri-ate, hyaline, 3-septate, not constricted,  $12-15 \times 4-5 \mu$ ; paraphyses septate, branched, with globular, olive-brown, glutinous tips  $5 \mu$  diam., forming a greenish-brown mazaedium; exciple prosenchymatous, hyaline at the base, gradually elongated and brown toward the margin.

Apotheciis sessilibus, superficialibus, singulis, patelliformibus, tenuiter membranaceis, .2-.5 mm. diam., brunneis; hymenio pallide alutaceo; ascis clavatis, breve pedicellatis, octosporis,  $50-65 \times 8-10 \mu$ ; sporis ellipsoideo-clavatis, 1-2-seriatis,  $12-15 \times 4-5 \mu$ ; paraphysibus septatis, ramosis, apice brunneis, mucosis, usque  $5 \mu$  latis, mazaedium olivaceum formantibus.

On decorticated twigs of *Abies*, Grand Mesa, July 2, 1930, R. W. D. 500-a.

On account of its prosenchymatous exciple, this fungus belongs in the Helotiaceae where the 3-celled spores place it in *Belonium*. According to Rehm, species of this genus have hyaline paraphyses, varying widely in form: lanceolate, filiform, swollen at the tip, simple or branched. In this material the paraphyses resemble those of *Dermatea*, but the thin membranous texture distinguishes it from members of that and related genera.

Several species of *Belonium* are described by Velenovsky (6, p. 176-177) on conifers, but all differ in size, color, dimensions of spores and character of the paraphyses.

**8. *LACHNUM CALYCVLAIFORME* (Pers.) Karst.**

Apothecia short-stipitate to sessile, scattered or gregarious, fleshy-waxy, densely tomentose, subglobose, Verona brown to snuff brown, 1 mm. diam., .7-1 mm. in height, opening small, circular, margin fimbriate, hymenium pale vinaceous-fawn to pinkish buff, stipe short, often lacking; asci cylindrical, apex obtuse, 8-spored,  $55-60 \times 5-7 \mu$ ; spores biseri-ate above, uniseri-ate below, elliptical-clavate, hyaline, unicellular,  $8-10 \times 1.5-2 \mu$ ; paraphyses hyaline, stiff, rather stout, longer than the asci, septate, unbranched, swollen to  $3 \mu$  near the narrowed tips; exciple pale, prosenchymatous, densely covered by bright yellow-brown,

tangled, verrucose, septate, flexuous hairs,  $200 \times 3-5 \mu$ , frequently bearing crystals on the pale tips.

On decorticated wood of *Salix*, Mesa Lakes, June 14, 1930, R. W. D. 240, June 18, 1930, 314; on *Populus tremuloides*, Mesa Lakes, June 18, 1930, 340-a, July 14, 1930, 652, July 18, 1930, 734-b.

This material was at first tentatively determined as *Dasyscypha albolutea* (Pers.) Rehm, but study of a specimen of the latter (Rehm Ascomyceten 1720, on *Ulmus*, leg. Vogel, Germany) demonstrates that in the Colorado fungus the hairs are darker and rougher and the asci and spores larger. The apothecia are also more frequently stipitate and globose than in *D. albolutea*. *Dasyscypha Fairmani* Rehm has still larger spores and smooth hairs.

*Dasyscypha albolutea* (Pers.) Rehm, *Lachnum calyculaeforme* (Pers.) Karst. and *L. fuscofloccosum* Rehm are very similar in general appearance, size of spores and in the slender paraphyses which appear to be intermediate between the lanceolate form characteristic of *Lachnum* and the filiform type of *Dasyscypha*. In this regard, Rehm (5, p. 898) describes *L. calyculaeforme* var. *latebriicola* as follows: "Paraphysen theils fädig, theils lanzettförmig spitz, die Schläuche überragend." The Colorado specimens examined agree with European material of *L. calyculaeforme* (Krypt. Exs. Vind. 1617, on *Betula alba*, coll. Keissler, Carniola). The hairs in *Dasyscypha albolutea* are nearly hyaline and echinulate, while those of *Lachnum fuscofloccosum* Rehm are smooth and brown. The three species are difficult to distinguish and it is possible that examination of more abundant material may prove them to be identical.

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## A NEW PREDACIOUS FUNGUS

J. S. KARLING

(WITH 5 FIGURES)

In the fall of 1935 while collecting species of Characeae for inoculation with *Diplophlyctis intestina* numerous thalli of *Sommerstorffia spinosa* Arnaud. and *Zoophagus insidians* Sommer. were found on filaments of *Nitella flexilis*. These aquatic fungi are to some degree epiphytic on a wide variety of algal filaments, and derive their nourishment from species of rotifers which they capture and devour. The latter fungus seems to be fairly abundant and has been found several times in Europe and thrice in America (7, 8, 9), while *Sommerstorffia spinosa*, according to the literature, appears to be more limited and has apparently been reported only twice each in Bulgaria (2, 10) and the United States.

The *Nitella flexilis* filaments on which our material occurred were collected in a small brook at Arcola, New Jersey, in early October and grown in battery jars in the laboratory throughout the fall and winter. In the course of time, however, *S. spinosa* and *Z. insidians* gradually disappeared as the supply of rotifers was exhausted, and it was not until approximately a month later that an effective method of growing *Monostyla* was developed which insured a constant supply of food. Accordingly, vials containing rotifers were added from time to time to the jars of *Nitella* in hopes of reviving the fungi. *Sommerstorffia spinosa* failed to reappear, and only a few mycelial fragments of *Z. insidians* were found. In the course of this search, however, another rotifer-capturing species was discovered which proved to be strikingly different from *Z. insidians* in two respects. Whereas the latter possesses only short peg-like branches for the capture of its prey this new species develops in addition elongated, tenuous predacious tentacles at the tips of the pegs. Furthermore, its mycelium, in the early and preabsorptive condition, is somewhat smaller in diameter than that of *Z. insidians*. These differences

have been so constant and marked in all filaments so far observed that there can be no doubt but what we are dealing with a new species. However, with the exception of these two chief characteristics the fungus is essentially similar to *Z. insidians* and undoubtedly belongs in the same genus. Accordingly, I am proposing the specific name *tentaculum* for this new member, with the view of emphasizing its outstanding structural character.

***Zoophagus tentaculum* sp. nov.**

Mycelium filamentous, greatly extended, 3–6  $\mu$  in diameter, hyaline, branched and continuous; possessing numerous relatively short specialized lateral branches, 15–35  $\mu$  in length and 3–5  $\mu$  in



FIG. 1. Thallus of *Z. tentaculum* before and after capturing its prey.

diameter, which bear one to five tenuous, predacious tentacles at the apex. Cytoplasm in the tips of the short lateral hyphae highly refractive; tentacles, 10–17  $\mu$  in length and 1.5 to 2  $\mu$  in diameter, and terminated by a small knob. Conidia or gemmae produced at the end of the long hyphae in acropetal succession, 40–80  $\mu$  in

length and 3–6.5  $\mu$  in diameter. Growing loosely epiphytic on *Nitella flexilis*; predacious and parasitic on species of *Monostyla*, *Diostylia*, etc.

#### STRUCTURE OF THE MYCELIUM

The thallus of *Z. tentaculum* is definitely filamentous and greatly extended as is shown in figure 1A. It appears to be strictly external and in no cases so far observed has it been found to penetrate and ramify the *Nitella* cells as Sparrow has described for *Z. insidians*. Most of my material has been found on *Nitella internodes* which had previously been killed by cooking in water and thus were in a state of disintegration. Even under such conditions the fungus mycelium remained entirely external. It appears thus to have merely a loose epiphytic relationship with the alga, and no differentiated anchoring organs such as are often seen in *Sommerstorffia* have been observed. In its early stages and particularly when the food supply is scant it may often consist of only a single isodiametric elongated filament with numerous short side branches which bear the predacious tentacles, figure 1A, but as it matures and captures a large number of rotifers it begins to grow very rapidly and branch freely so as to form often a conspicuous web around the *Nitella* cells. In figure 1A is shown a filamentous thallus with eight short branches which was found growing rather closely applied to a *Nitella* internode. After this drawing had been made the specimen was removed from the slide and placed in a vial full of *Monostyla* and other rotifer species. When examined again under the microscope two hours later, it had captured four rotifers, three of which were still actively kicking and jerking to escape. Its appearance and structure seventy-two hours later is shown in figure 1B. It has elongated considerably, developed five long lateral branches, numerous additional organs of prey, and captured eighteen rotifers. Under such conditions of food supply, the mycelium increases markedly in diameter towards the growing end and may become quite irregular in outline. Figure 2 shows the terminal portion of a richly branched thallus with ten captive rotifers in various stages of consumption. The irregular outline and increased diameter of the mycelium is particularly evident in this figure.

As to structure, the mycelium is non-septate and continuous, branched, hyaline and varies from 3 to 6  $\mu$  in diameter. Its content is finely granular with numerous suspended round, irregular, rod-shaped and elongated bodies, granules and globules. These are essentially similar to those described by Sommerstoff in the cytoplasm of *Z. insidians*, but apparently not as large and obvious. Whether or not they are chondriosomes remains to be determined



FIG. 2. An enlarged terminal portion of the mycelium with ten captive rotifers.

from study of fixed and stained material. Streaming and circulation of the cytoplasm is usually quite marked but not as conspicuous as in *Z. insidians*. In this process the suspended bodies are passively carried along, although in many instances it may appear as if they possess independent motion. This, it seems to me, is an optical illusion, because the medium in which they are suspended is often so homogeneous optically that its movement may be readily overlooked. As a consequence the various bodies frequently seem

to be moving of their own accord. So far no nuclei have been recognized in living material.

The lateral branches which bear the tentacle vary from 15 to 36  $\mu$  in length, depending to some degree on the supply of food; and with the exception of the apex, have the same appearance as the remainder of the mycelium. Before extensive feeding begins they are usually slightly smaller in diameter than in the main filament. When the mycelium lies closely applied to a *Nitella* internode they are formed on only one side and at right angles to the main axis, so that they stand out and away in an erect position. On the other hand, when the thallus becomes detached they develop on all sides, particularly if the supply of food is abundant. The cytoplasm in the upper end and apex of these short branches is quite different optically from that in the remainder of the thallus. It appears more dense and sharply refractive, and in this respect it is similar to that in the predacious branches of *Z. insidians* and *S. spinosa*. The tentacles vary from one to five, but four is the predominating number, according to my observations. They may be borne terminally on the main axis of the mycelium, figures 1 and 2, as well as on the short lateral branches, and branch occasionally, figure 3J. They vary from 10 to 17  $\mu$  in length and 1.5 to 2  $\mu$  in diameter, and are usually terminated by a small knob, which apparently plays an important rôle in the capture of rotifers. As a general rule they are slightly swollen at the base. The tentacles are filled with a homogeneous hyaline cytoplasm, which usually does not appear as refractive as that in the tip of the branch on which they are borne; it is thus still uncertain whether or not this modified cytoplasm always extends into the tentacles themselves. At least they are generally free of suspended bodies and granules.

Successive developmental stages of the side branches and tentacles are shown in figure 3A to 3F. The former begin as lateral buds on the mycelium, figure 3a, which rather rapidly attain a length varying from 15 to 36  $\mu$  if the thallus is well nourished. Subsequently the apex becomes somewhat blunt, figure 3D, and the initials of the tentacles begin to appear as small papillae. In the meantime, the cytoplasm in the apex begins to show its refractive character and density. The incipient tentacles are at first slightly pointed at the apex, figure 3E, but as they attain their mature



length the tips enlarge to form the characteristic knobs, figure 3F. These rarely become more than one and a half times the diameter of the filaments which bear them. Figure 3G shows a portion of a terminal branch with a single tentacle and the rudiments of three others, while figure 3H illustrates a lateral branch with only two tentacles. The appearance of tentacles when viewed from above is shown in figure 3I. This latter figure shows clearly the manner in which the tentacles stand out from the short hyphae. At maturity they appear to be quite resilient and flexible in texture. They may readily be bent by a micro-dissection needle, and when

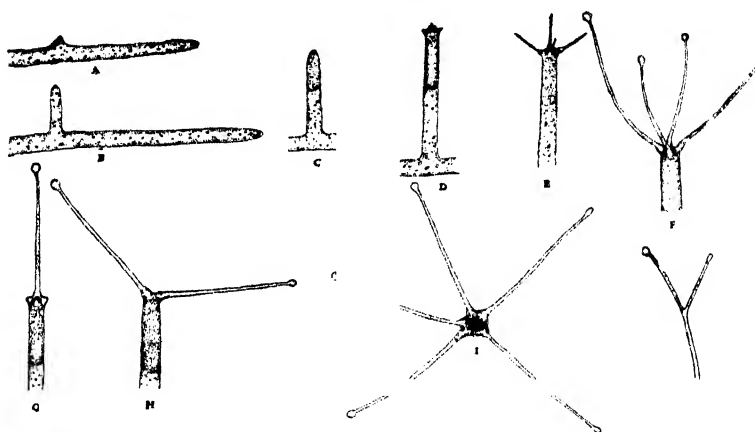


FIG. 3. Stages in the development and variations of the lateral branches and tentacles.

the pressure is released, they spring back into their original positions. In no cases so far observed have they been found to be elastic or contractive. That they are extremely tough and resistant is attested by their durability after capturing a rotifer. For more than an hour the captive animal makes every effort to free itself by jerking, turning over, and clamping down repeatedly on the tentacle, and although the latter may thus become twisted and bent back and forth an indefinite number of times it seldom breaks.

#### FEEDING HABITS OF ZOOPHAGUS TENTACULUM

Each of the tentacles described above is capable of capturing a rotifer, and it is at once obvious that the effectiveness of *Z. ten-*

*taclum* is thereby increased many times beyond that of *Z. insidians* and *Sommerstorffia spinosa*. In two instances I have observed as many as three rotifers attached to a single branch bearing four tentacles, figure 2E, but such cases are quite rare. As is shown in figures 3F and 3I the tentacles usually stand out somewhat like fingers on the palm, and are thus enticing bait for any foraging species of *Monostyla*. As the feeding rotifer comes in contact with a tentacle the latter is drawn into the mouth by the beating cilia, and the animal thus finds itself caught as it tries to move away. According to my observations, the tentacle does not appear to be distasteful or immediately poisonous to the rotifer, for the latter does not become aware of its presence until it begins to swim away. In many instances the rotifers may continue feeding in the immediate vicinity for some time after being caught. Quite frequently one or all of the tentacles down to the apex of the lateral branch may be engulfed, figures 2A and 2B. As to the actual process by which the capture is effected we have very little concrete knowledge. In *Z. insidians* and *S. spinosa* the capturing organs are reported by Sommerstorff (6), Arnaudow (1, 2), Mirande (5), and Sparrow (7) to exude a drop of sticky fluid which adheres to the tip, and as the rotifer engulfs the apex it thereby becomes caught. Although the actual capture of more than a hundred rotifers have so far been observed, I have yet failed to find any exuded drops in connection with the tentacles of *Z. tentaculum*. I have also failed to observe them in *Z. insidians*. It is not, inconceivable, however, that the knobs in the former species may be punctured when eaten, and thereby release an adhesive fluid. If such is the case it is obvious that this fluid must be extremely tenacious in order to hold the rotifers until they die. So far no contraction of the tentacles has been observed to occur before or after the capture.

Death of the prey usually ensues in less than two hours. To date one hundred and twenty-six captures have been seen, and careful records have been kept of the length of time the captives remained alive. The shortest execution observed required seventy, and the longest one hundred and eighteen minutes. Death is thus a comparatively slow process. As has been described above, the rotifer is quite active and vigorous when first caught, but after

approximately three-quarters of an hour has elapsed it becomes more quiescent with only occasional flips of the tail. Continual efforts, however, are made to regurgitate the engulfed tentacle, which are frequently accompanied by spasmodic contraction of the viscera. Finally, as the rotifer dies the muscles relax and the mouth usually opens wide. As to the successive internal cytological changes which occur in the rotifer as it is being consumed, very little is known at the present time. They doubtless vary

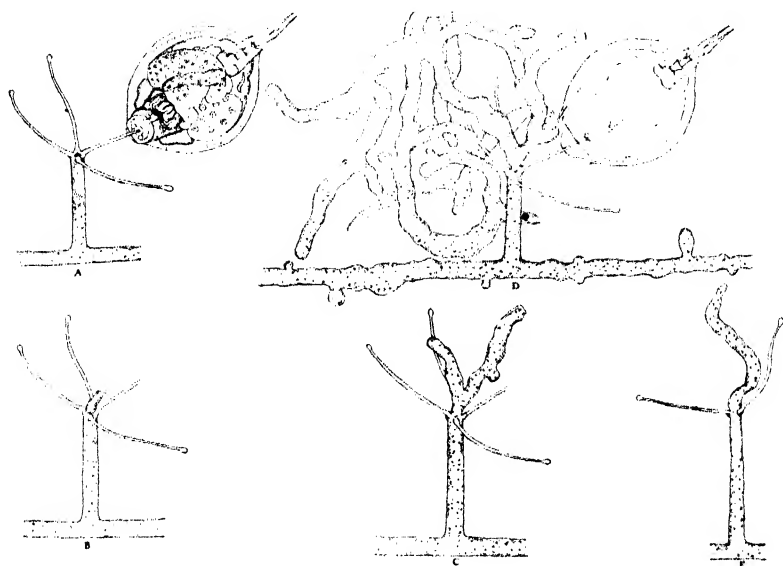


FIG. 4. Successive stages in the development of "external" hyphae in the vicinity of a captured rotifer.

somewhat with the type and degree of invasion. Abundant material in all stages of infection and consumption has been fixed, and a report of the changes together with cytological study of the parasite itself will be made later.

If the rotifer has engulfed a tentacle down to the branch, the latter generally grows into the mouth, figure 2*A* and 2*B*, and forms a tangled and coiled mass of tubular hyphae which consume the body contents. These hyphae are usually somewhat smaller in diameter than the main axis of the mycelium and are to be regarded in most cases as haustoria. On the other hand, when only

the tip and knob of a tentacle is engulfed the branch may not enter the rotifer at all but elongate and branch on the outside. In such cases it is obvious that the tentacles act not only as organs of prey but haustoria or absorbing organs as well. Figure 4A shows a rotifer which has recently been captured at the end of a tentacle. Within an hour and a half, even before the animal was completely dead, a noticeable change appeared in the tip of the branch, as is shown in figure 4B. It is slightly elongated and has put forth a small bud beyond the base of tentacles. The same branch three hours later is shown in figure 3c. Its appearance six days later is shown in figure 4D. The entire rotifer with the exception of the outer chitinous shell has been consumed, and the tip of the branch has been transformed into a snarl of elongated, branched, irregular and gnarled hyphae. Likewise, the main axis of the mycelium has increased in diameter and become uneven and bumpy in contour quite similar to that of *Z. insidians* as described by Gieckhorn. Furthermore, an adjacent short hypha, figure 4E, bearing two tentacles has also begun to elongate at the apex. The cytoplasm in the hyphae and main mycelium under such conditions usually appears denser and more homogeneous, while the streaming becomes sluggish and almost imperceptible. The preying tentacle in figure 4D has undergone but little change: it is frayed at the end, and somewhat extended. The development of external hyphae such as is shown in figure 4 is the most extended of any so far observed and is thus exceptional in many respects. In the majority of cases the development has not proceeded much beyond the stages shown in figures 2C and 2D.

In a few thalli the tentacle bearing branches may fail to develop either intra- or extramatrical hyphae, and the absorbed food is used for the growth and development of the thallus as a whole. In such cases a marked change is soon visible. The mycelium begins to elongate, increase in diameter and branch, as is shown in figure 2. Sometimes the other branches which bear the tentacles may be stimulated to intercalary growth, and may occasionally elongate at the apex as in figure 4E.

As to its hosts, *Z. tentaculum* has been found chiefly on species of *Monostyla*, particularly *M. solidus*, although members of *Distyla* have twice been found captives. From the data at hand,

it thus appears to be somewhat more limited in host range than *Z. insidians*, which according to Sommerstorff, Arnaudow, and Mirande is capable of capturing and devouring species of four rotifer genera and one infusorian. I have frequently found species of *Amoeba*, *Actinophrys*, *Actinosphaerium*, *Paramoecium*, etc., engulfing the tentacles without being caught or suffering any serious consequences. *Amoeba proteus* has once been observed to engulf and absorb the elongated gemmae or conidia. The unusual method which these predacious fungi employ in capturing their hosts suggests that the structural relationships between the two may be rather specific, and particularly adaptive on the part of the parasites. In some of the more highly specialized flowering plants, according to current conceptions, the floral parts are adapted to insect pollination, and it is not at all inconceivable that the spines, tentacles and adhesive fluid, if the latter proves to be such, in these fungi have also gradually evolved and adapted themselves specifically to the mouth parts of rotifers.

#### CONIDIA

Numerous elongated and somewhat spindle-shaped gemmae or conidia have frequently been found in my cultures of *Z. tentaculum*. Their formation and development is fundamentally similar to the same process described by Arnaudow for *Z. insidians*, with but minor variations. According to my observations, conidial production occurs only after a prolonged feeding period in which the mycelium appears to become unusually well nourished. This is evidenced by its somewhat irregular contour, larger diameter, and the marked density and sluggishness of the cytoplasm. Gemmae are formed only at the terminus of the main mycelium or the lateral branches, other than those which bear the tentacles. In figures 5A to 5I I have illustrated the progressive developmental stages at the end of a lateral branch. Conidial bearing branches may often be recognized in their early stages by the presence of a constriction near the apex. This results in the development of a bud-like growth at the tip, which becomes the rudiment of a conidium. As it elongates it usually increases markedly in diameter at the equator, and the constriction or isthmus of the branch

becomes more pronounced and conspicuous. A later stage is shown in figure 5C. The conidium is considerably longer and thicker with the apical end distinctly rounded, while the isthmus has become narrower and longer. The final separation of the conidia from the branch or conidiophore is quite unusual and characteristic, figures 5D to 5F. The isthmus constricts more and more until practically no cytoplasm is to be seen in it, and finally

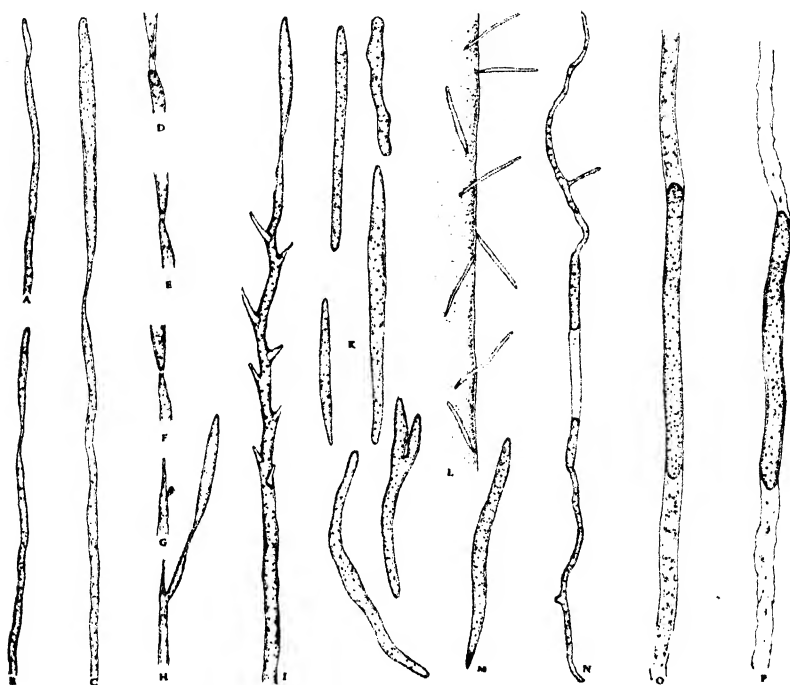


FIG. 5. Stages in the formation, structure, habitat and germination of gemmae or conidia.

the walls seem almost to merge. The cytoplasm in the basal end of the conidium and the apex of the conidiophore then retract slightly, figure 5E, forms a definite membrane which becomes modified and eventually seals up the ends of the two. The walls of the isthmus then break at a point midway between, and the conidium is thereby abstricted, as is shown in figure 5F. It is to be noted that no cross walls are formed in the process. Additional conidia may be formed on the same branch. These begin similarly

as small buds shortly behind the pointed apex of the conidiophore, figure 5G, and mature in the same fashion as the primary conidium. As a result of the acropetal succession of conidia an old conidiophore may have a number of sharp peg-like branches along its apical end, which frequently gives it a somewhat zigzag appearance, as is shown in figure 5I.

As the conidia separate from the conidiophores they may be carried away in the water. With further development the basal end increases in diameter and loses its sharply pointed appearance, so that it is now and then difficult to differentiate between the two ends, figure 5K. At maturity the gemmae are usually elongated and spindle-shaped, as is shown in figure 5K. Occasional branched ones still attached to the conidiophore have also been observed. They may vary from 40 to 80  $\mu$  in length and 3 to 6.5  $\mu$  in diameter. Their cytoplasm appears quite dense without any conspicuous vacuoles and imbedded refractive bodies. No streaming of the cytoplasm has so far been seen.

In a number of microscopic mounts numerous conidia have been found standing out at right angles to the internode of *Nitella* as if definitely attached, as is illustrated in 5L. The basal ends of these were distinctly wedge-shaped, and filled with a sharply refractive substance, figure 5M, and frequently had the appearance of rudimentary anchoring organs. It is thus not inconceivable that in the early stages of development species of *Zoophagus* may be more epiphytic in their habitat than is generally believed.

Numerous germination stages of the conidia have been found, figure 5N. The germ tubes may arise at both ends, and occasionally in the middle. They grow out into elongated filaments, and soon develop short lateral branches which bear the tentacles. Extensive branching of the main axis, however, does not generally occur until the food supply is augmented from captive rotifers.

Another method of reproduction or perpetuation of the thallus frequently occurs as it gets older. Quite often portions of the mycelium may die or get killed, which leaves regions in between alive, figure 5O. The protoplast immediately develops membranes at the ends of the living sections, which shortly take on the character of convex walls, as Sommerstorff has described in *Z. in-*

*sidians*. The living portions of the mycelium are thus shut off, and as the remainder of the thallus disintegrates they lie free in the water or on the *Nitella* cells and look strikingly similar to blunt conidia, figure 5P.

So far neither zoösporangia, zoöspores, oögonia nor antheridia have been found. However, the general structural characteristic and method of feeding are so similar to those of *Z. insidians* that the same type of asexual and sexual reproduction will doubtless be found to prevail in this species as well.

#### SUMMARY

1. *Zoophagus tentaculum* has been found growing loosely epiphytic on filaments of *Nitella flexilis* from Arcola, New Jersey, as a predacious parasite of species of *Monostyla* and *Distyla*.

2. The thallus consists of an extended, hyaline, continuous, branched, and filamentous mycelium with relatively short, specialized lateral branches which bear from one to five elongated tenuous predacious tentacles at their apices.

3. The tentacles are terminated by a small knob, and are thus the specialized organs for capturing rotifers. As they are drawn into the mouth of the feeding animal, the latter becomes caught in some manner and is unable to break away, and death ensues in less than two hours. The tentacles may also serve as haustoria or organs of absorption when no hyphal haustoria are developed in the captured rotifer.

4. When the tentacles are engulfed down to the apex of the short specialized branches, the latter grow into the mouth of the rotifer and develop highly coiled and richly branched tubular haustoria, which absorb the contents of the host in a few days.

5. Cylindrical and spindle-shaped gemmae or conidia are produced in acropetal succession at the ends of elongated lateral and terminal branches.

6. Neither zoösporangia, antheridia, nor oögonia have so far been observed.



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# EVIDENCES FOR THE POSSIBLE OCCURRENCE OF SEXUALITY IN DIPLOPHLYCTIS

F. K. SPARROW, JR.

(WITH 2 TEXT FIGURES)

The purpose of this note is to record the fact that there are evidences which seem to point to the existence of sexuality in the chytridiacean genus *Diplophlyctis*.

The morphology and development of this striking inhabitant of dead cells of the Characeae have been the object of study by several investigators, notably Zopf<sup>1</sup> and more recently Karling.<sup>2</sup> The latter's series of observations on the sequence of events in the establishment of the thallus (which the writer can confirm) are particularly noteworthy. However, neither of these investigators presented any material which might help us answer the most pertinent question in the life-history of this fungus, namely: Is formation of the resting spore preceded by any type of sexual process?

In material of *Nitella*, obtained in October 1934 by the writer from Ithaca, N. Y., through the kindness of Prof. W. K. Stone, there occurred an abundance of resting spores in all stages of development. In examining this material it was found that, under particularly good optical conditions and a favorable disposition of the opaque host contents, in addition to the typical large, apophysate, spiny resting structures, there could also be detected minute, scarcely visible thalli. These were found in almost constant association with *maturing* resting spores (not old ones with a disintegrating rhizoidal system). They were about 10  $\mu$  high by 5  $\mu$  in diameter, possessed a rhizoidal system of limited extent, with or

<sup>1</sup> Zopf, W. 1884. Zur Kenntniss den Phycomyceten I. Zur Morphologie und Biologie der Ancylisteen und Chytridiaceen, zugleich ein Beitrag zur Phytopathologie. Nova Acta Leop. Deutsch. Akad. Nat. 47: 141.

<sup>2</sup> Karling, J. S. 1928. Studies in the Chytridiales II. Contribution to the life history and occurrence of *Diplophlyctis intestina* (Schenk) Schröt. in cells of American Characeae. Am. Jour. Bot. 25: 204.

without an apophysis, and in every way resembled the very immature thalli. When associated with fully mature resting spores they were empty, adding further to their invisibility.

In particularly favorable specimens it could be seen that there is a definite connection between the rhizoidal systems of these two types of structures (FIG. 1). This anastomosis is usually achieved

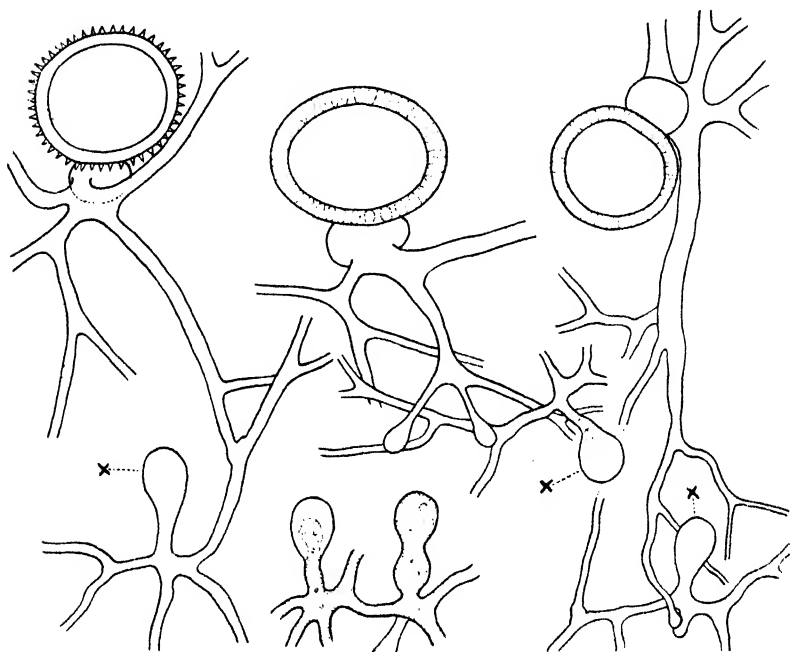


FIG. 1. Four typical instances of association and anastomoses of thalli in *Diplophlyctis intestina*. The smaller thalli which have apparently contributed their content to the formation of the resting spore are marked "x."  $\times 1200$ .

by the rhizoid of the larger body which may fuse laterally with one or two rhizoids of the other; less often the reverse situation is observed. Sometimes the rhizoid of the receptive thallus connects directly with the apophysis or point of origin of the rhizoids of the smaller plant (FIG. 2). At the point of contact, the rhizoid is frequently slightly distended as if a minute appressorium had been formed. Observations would also seem to indicate that connection of the two thalli and transference of material may take place at a

very early stage in thallus development. In many cases the contributing thallus has apparently been emptied just after the formation of the rhizoids and prior to the formation of the apophysis. Such empty thalli often possess a foamy content or a minute, refractive globule.

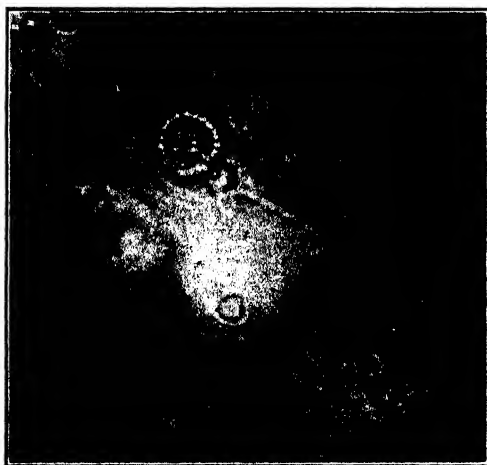


FIG. 2. Photomicrograph of association of a resting spore of *Diplophlyctis* and a smaller thallus. One of the rhizoids of the resting spore has made contact with the rhizoidal system of the smaller thallus, indicated by an arrow.  $\times 357$ .

The actual transference of materials into the receptive thallus could not be detected. For this reason, but more especially because of the fact that the structures involved are so minute, the writer feels that further observations are needed by other investigators before it can be said definitely that this association and union of thalli is, as he strongly suspects, the result of a *Siphonaria*-like type of sexuality.

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# THE USE OF ULTRA-VIOLET IRRADIATED CULTURE MEDIA FOR SECURING BACTERIA-FREE CULTURES OF SAPROLEGNIA<sup>1</sup>

IRVIN H. BLANK AND WESLEY N. TIFFNEY

(WITH 1 FIGURE)

In almost all mycological work it is essential to secure and to maintain pure cultures of the fungi being investigated. Yet in many cases, cultures of the fungi, free from bacteria, are extremely difficult to obtain. This preliminary step in an investigation is often tedious and disproportionately time-consuming and hence the major objective of one's research is often long delayed.

The Saprolegniaceae, as a group, are especially troublesome to isolate. This difficulty arises because of the following conditions: these fungi occur in nature accompanied by large numbers of bacteria; usually the fungi themselves are slower in growing than the bacteria; the fungi, when grown on agar, are surrounded by a liquid film, by means of which the bacteria readily accompany the hyphae; the fungi do not grow satisfactorily in the presence of the commonly used bacterial inhibitors; the fungi have temperature and water requirements similar to those of bacteria. Each of these conditions adds to the difficulty of isolation by the common method of repeated transfer, since the hyphae invariably are accompanied by adhering bacteria.

The methods which have been employed in obtaining pure cultures of the Saprolegniaceae were ably reviewed by Kauffman (4). These methods as well as those more recently developed not only for the Saprolegniaceae but also for other fungi, may be roughly classified as either mechanical or chemical.

The mechanical methods as advocated by Klebs (5), Horn (2), Kauffman (4), Pieters (9) and others, place the mixed culture of

<sup>1</sup> Contribution No. 139 from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University.

the fungus and bacteria on a semisolid culture medium and then repeatedly transfer to a fresh medium the more or less bacteria-free marginal regions of growth until a pure culture is obtained. The following modifications of this general method have been used. Since the temperature ranges of growth for the Saprolegniaceae are usually below those for bacteria, the growth of the bacteria is inhibited more than that of the fungus by holding the contaminated plates at relatively low temperatures. If, in addition to lowering the temperature, the plates are held in a vertical position, the liquid surrounding the hyphae drains to the bottom carrying with it the bacteria and leaving the hyphae at the tops of the plates relatively free from bacteria. Very dilute suspensions of zoöspores from well washed sporangia may be smeared or sprayed onto suitable, semisolid media, thereby mechanically separating the zoöspores from the bacteria.

The chemical methods of isolation employ the principle of growing the contaminated culture on a medium which favors the growth of the fungus but inhibits the growth of the bacteria. In order to obtain such a medium, antiseptics are added to the standard culture media in low concentrations. Boric and salicylic acids were used by Maurizio (7), chlorine by Lafar (6), and chloride of lime by Melin (8).

General experience has shown, however, that the attainment of pure cultures of *Saprolegnia* by the foregoing methods is a laborious, difficult process, and not always successful. The junior author, following the accepted procedure of washing the original material in several changes of distilled water and then repeatedly transferring from the margin of the colony, has sometimes failed to obtain successful isolations. The same lack of success frequently attends modifications of this procedure.

The fungus, though evident in the original material, may fail to appear on artificial media because the growth is completely inhibited by the more rapidly developing bacteria. There is need, therefore, for some method that will simply but effectively achieve isolation by means of inhibiting the bacteria and yet permitting the fungus to grow naturally.

A modified chemical method by which this differential inhibition might be obtained was suggested by some work of Blank and Ar-

noid (1). This work showed that ultra-violet irradiation (2537 Å) of culture media containing carbohydrates so alters the media that they will no longer support the growth of *B. subtilis*. Unpublished work has shown that the growth of other bacteria and common molds can be similarly inhibited. Generally it has been

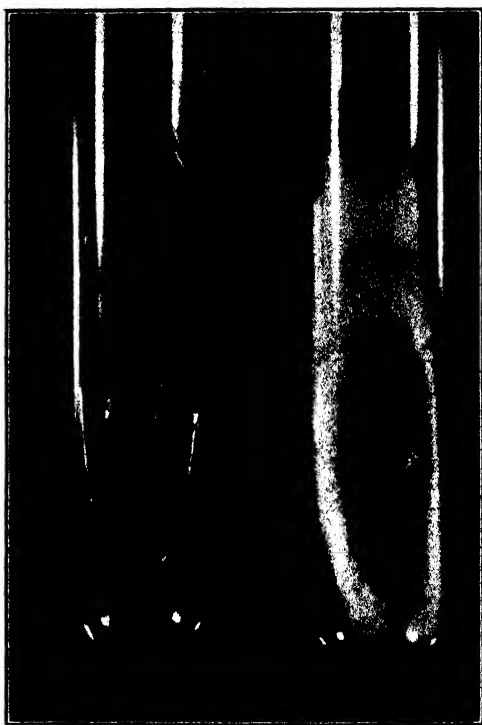


FIG. 1. Potato-dextrose agar cultures obtained from transfers from the 24-hr. growths on non-irradiated medium A (left) and irradiated medium B (right). Note that tube A shows the predominating growth of the bacteria which are completely absent in tube B.

found, however, that a much greater dosage has been required to inhibit the growth of fungi than is necessary to inhibit the growth of bacteria. Thus it would seem that the medium and dosage probably could be so regulated that when mixed cultures of fungus and bacteria are inoculated on the surface of an irradiated culture medium, the fungus would grow but the bacteria would be inhibited.

With this possibility in mind, a medium composed of 1.0 g. of peptone, 5.0 g. of levulose and 20 g. of agar per liter was prepared, sterilized by autoclaving for 15 minutes at 15 lbs. pressure and then 5.0 ml. quantities aseptically placed in 4.5 cm. sterilized petri dishes. Several of these dishes were held uncovered at 29 cm. from a mercury vapor lamp (manufactured by the Hanovia Chemical and Manufacturing Co.) and irradiated for three hours. The lamp was operated on an arc current of 3.2 amperes with 70 volts across the arc. A photograph of the spectrum of irradiation showed lines at 3125, 3021, 2967, 2920, 2894, 2804, 2652, and 2537 Å. The total intensity of the radiation at the distance of 29 cm. was 6.27 ergs per sq. mm. per second.

Specimens of *Saprolegnia* sp. taken from a dead frog found in a marsh were brought into the laboratory in water taken from the same source. Transfers were made from these specimens directly, without washing, onto the centers of irradiated and non-irradiated dishes of the above medium and allowed to grow at room temperature (approx. 20° C). A good growth of *Saprolegnia* with very little bacterial contamination appeared on the irradiated medium. The non-irradiated medium showed a heavy bacterial development with relatively little growth of *Saprolegnia*. After 24 hours, transfers were made from the edges of each culture and placed on tube slants of potato dextrose agar. Figure 1 shows the growth of these slants after 36 hours incubation at room temperature. Tube A illustrates the development of microorganisms transferred directly from the growth on the non-irradiated medium. Although the fungus was transferred, the bacterial associates grew so rapidly that they completely inhibited the fungus. Tube B is a direct transfer from the growth on the irradiated plate and shows a good growth of the fungus, completely free from bacterial contamination.

In this method, the inhibition of bacteria results from the presence of a growth-inhibiting substance which the irradiation produces by a chemical change of the carbohydrate fraction of the medium. The radiant energy is strongly absorbed at the surface of the medium, but the toxic materials produced there diffuse through the entire volume of the medium. The amount of growth inhibition is dependent upon the final concentration of the toxic



material. The most efficient utilization of available energy is thus obtained when a small volume of medium is placed in such a container as to expose a large surface. This was obtained in the above experiment by the use of only 5.0 ml. of medium in a 4.5 cm. petri dish.

Any of the common carbohydrates may be incorporated into the culture medium, to act as the source of the toxic material. Indeed, inhibition will result if only agar is irradiated. For any specific dosage, however, a maximum concentration of toxic material is obtained when levulose is used. The presence of proteins in the medium probably tends to diminish the inhibitive action and hence their concentration should be held at a minimum. These considerations explain why levulose was used in place of the more commonly used carbohydrates and why the concentration of peptone was held so low.

In addition to the original test described above, other isolations were made from similar *Achlya* and *Saprolegnia* collections. These were taken from decaying organic substrata found in ponds and streams near the laboratory. At times it was necessary to subculture for a second time on irradiated material to secure a pure culture, but in every case successful isolations were attained with considerably less difficulty than would have been involved in any of the more commonly used methods.

This method of isolation is offered in the hope that it will be of general use in obtaining bacteria-free cultures of fungi. Such a method, for example, might have prevented the erroneous identification of *B. coli* as the causative agent of coconut bud-rot (Johnston (3)), and made possible much earlier the delayed correct diagnosis of *Phytophthora* as the causal organism of this disease (reviewed by C. M. Tucker (10)). This work further suggests that the Dermatomyces might be obtained more easily from clinically positive lesions if the scrapings are cultured first on an irradiated medium. In this manner, the growth of bacteria normally present on the skin would be inhibited and the pathogenic fungus allowed to grow. It is to be expected that certain modifications in the above technique, as regards composition of medium, dosage, etc., will be required if this method is to be successfully used on other organisms.

## SUMMARY

Bacteria-free cultures of *Saprolegnia* were readily obtained from badly contaminated sources by first growing the organism on an ultra-violet-irradiated medium containing levulose, peptone and agar. The ease of obtaining bacteria-free cultures by this method depends upon the fact that the irradiation so alters the culture medium that growth of bacteria is greatly inhibited with little or no inhibition of the development of the fungus. It is thought that this method will be applicable to the isolation of other fungi.

The authors wish to acknowledge their indebtedness to Professor William H. Weston Jr. for the helpful suggestions offered during this investigation.

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## TWO SPECIES OF PHYSALOSPORA IN ENGLAND

NEIL E. STEVENS

The relationship of the very similar fungi found on rotten apples by Berkeley in England and by Peck in New York and in each case named *Sphaeropsis malorum* has been the subject of much discussion and some controversy.

The writer (6) has elsewhere given in detail the reasons for his opinion that they are distinct species most easily distinguished by the size and shape and especially the time of coloring of the pycnospores, also that the most appropriate name for Peck's fungus is *Physalospora obtusa* (Schw.) Cooke and for Berkeley's *Diplodia mutila* (Fries) Mont. The present paper reports the finding in England of the ascogenous stages of both these fungi and the development of the pycnospores in pure culture from ascospores. This is apparently the first time the life history of *D. mutila* has been worked out.

### PHYSALOSPORA OBTUSA (SCHW.) COOKE IN ENGLAND

That the ascogenous stage of the fungus long known as *Sphaeropsis malorum* Peck is a species of *Physalospora* was proved in pure cultures more than 20 years ago by Hesler (3) and by Shear and Beckwith (5). During the past 15 years the writer has grown the pycnospores of this fungus in pure culture from ascospores collected on many hosts in the southeastern United States. While this by no means precludes the possibility that an indistinguishable pycnidial fungus might be produced from a quite different ascomycete it seems to render unwarranted the declaration of Petrak and Sydow (4, p. 73-74) regarding this species that "Um weitere Konfusionen zu vermeiden, sei hier noch ausdrücklich betont, dass diese Art in den Entwicklungskreis einer echten Cucurbitariacee, höchstwahrscheinlich zu *Oothia Pyri* Fuckel gehören muss und alle Angaben, welche diesen Pilz mit einer *Melanops*—(*Botryosphaeria*

oder *Physalospora*) Art in Verbindung bringen, grundfalsch sind."

The publication of so positive a statement also seems to make it worth while to record the finding in England of *Physalospora obtusa* (Schw.) Cooke, which is the ascus stage of *Sphaeropsis malorum* Peck.

Several weeks' search in England during the summer of 1930 by Dr. C. L. Shear and the writer resulted in finding only one lot of ascospore material, which produced in pure culture typical pycnidia of *Sphaeropsis malorum* Peck. This was found on hawthorn, probably *Crataegus oxyantha* L., at St. Ives, Hunts. Although there appeared to be no reasonable doubt as to the accuracy of these results it seemed unwise to make a report on the basis of a single specimen, particularly one in which no pycnosporos were found on the host. During 1930 they did find, however, three lots of *Diplodia mutila* (Fries) Mont., two on ash (*Fraxinus excelsior* L.) and one on apple (*Pyrus Malus*).

Mr. E. W. Mason, of the Imperial Mycological Institute, knowing of our interest in this group of fungi, sent late in 1934 two small specimens of *Physalospora*, hosts unknown, one of them probably apple, which he had received from the Reverend J. H. Adams, Landulph Rectory, Saltash, Cornwall. As they had been collected nearly a year earlier, the spores did not germinate. The specimens did indicate, however, the vicinity of Saltash as a suitable locality to search for more ascospore material. Several days' collecting in August 1935 resulted in securing, with the assistance of Mr. Adams, several good collections on apple prunings from Landulph Parish and one on hawthorn from the Central Park in Plymouth, England, which showed both pycnosporos and ascospores of *P. obtusa*. Single spore cultures of these ascospores produced abundant pycnosporos typical of *Sphaeropsis malorum* Peck. The ascospores themselves agreed closely with those found in the United States, except that they may average slightly larger. Certainly there seems no doubt as to the identity of the American and English specimens. The presence of the pycnidial stage of this fungus in England and on the continent of Europe has long been known; indeed, it was distributed under the name *Sphaeropsis*

*Mali* (West) by Vize in 1888 as number 539 in his *Micro-Fungi Britannici*.

THE ASCOGENOUS STAGE OF *DIPLODIA MUTILA* (FRIES) MONT.  
(*SPHAEROPSIS MALORUM* BERK.)

The discovery of *Physalospora obtusa* (Schw.) Cooke in England was incidental to a search for the perfect stage of *Sphaeropsis malorum* Berk. This search was wholly unsuccessful in 1930 and would almost certainly have been so in 1935 but for the assistance of Mr. Adams. In addition to the material from hawthorn and apple ascospores of which produced in pure culture pycnosporos typical of *S. malorum* Peck, a single specimen of *Physalospora* found on ash and one of those on apple at Saltash proved to have ascospores somewhat larger than any hitherto found in England, and single ascospore cultures made from these produced early in January 1936 pycnosporos typical of *Diplodia mutila* (Fries) Mont. (*S. malorum* Berk.).

The differences between the perfect stages of the two fungi here discussed are apparently confined to the size of the ascospores. Those of *Physalospora obtusa* measure  $23$  to  $38\mu \times 7$  to  $13\mu$ , mostly  $26$  to  $34\mu \times 7$  to  $12\mu$ , while those of the other fungus measure  $30$  to  $39\mu \times 12$  to  $16\mu$ , mostly  $30$  to  $36\mu \times 13$  to  $14\mu$ . The spore measurements overlap somewhat and on the basis of the perfect stage alone one might well hesitate to consider them distinct species. These differences are more readily observable, however, than the measurements would suggest, for the moment that Mrs. A. F. Kempton, who made all the cultures and who has examined much material of *Physalospora*, saw spores of the fungus on ash she was sure that this was "a different fungus." Moreover, the ascospores of this fungus on ash approach even more closely in size the tropical and subtropical species *P. rhodina* or the northern *P. glandicola* than they do *P. obtusa*. Yet the pycnosporos of these two fungi are so very different that no one would consider including either one of them in the same species with the fungus found at Saltash. The accumulating evidence indicates that most of the species of *Physalospora* are more easily recognized in the pycnidial than in the perithecial stages.

Deciding on the proper name for this fungus raises the usual difficulties. It is apparently not *Physalospora Cydoniae* Arnaud, the ascospore size of which is given (1) as  $23 \times 11 \mu$ . There is, of course, no certainty as to what the pycnidial stage of *P. Cydoniae* might be since Arnaud's suggestion that it is *Sphaeropsis pseudodiplodia* is based merely on association. Nor has the writer thus far been able to find any described species to which the perfect stage of *Diplodia mutila* may with reasonable certainty be referred. It thus appears best to cite it as **Physalospora mutila** (Fries) N. E. Stevens, comb. nov. with the hope that someone will shortly find an older valid name and reduce this to synonymy. Synonyms of the pycnidial stage were given by the writer (6, p. 547).

Pycnidia simple or compound in black stromata, variable in size up to 2 mm. in diameter. Pycnosporos at first one-celled and hyaline with a thick glassy wall, usually remaining in this condition for a long time, some of the spores usually becoming brown and septate;  $20$  to  $27 \mu \times 10$  to  $16 \mu$ , mostly  $25$  to  $27 \mu \times 10$  to  $12 \mu$ . Perithecia in stromata similar to the pycnidial or in the same ones. Paraphyses numerous, branched, interwoven, and apparently anastomosing, as in all fungi of this genus. Asci regularly eight-spored. Ascospores hyaline and nonseptate, a few later becoming two-septate;  $30$  to  $39 \mu \times 12$  to  $16 \mu$ , mostly  $30$  to  $36 \mu \times 13$  to  $14 \mu$ .

This fungus differs from *Physalospora obtusa* chiefly in the larger size of the ascospores, and the size, appearance and time of coloring of the pycnosporos. Type specimen on cut stick of *Fraxinus excelsior* L. at Saltash, Cornwall, England.

ANOTHER PYCNIDIAL FUNGUS (*DIPLODIA SARMENTORUM* FRIES) ON  
THE SAME HOSTS

The folly of attempting to decide matters of life history in this group of fungi on the basis of association on the host was again illustrated by the studies of the material from England. On the ash stick which bore the ascospores from which *Diplodia mutila* was produced in culture were found a few pycnidia containing pycnosporos of this species. Much more common and abundant, however, and closely associated with the fungus in question were pycnidia very similar in size and general appearance but containing

spores which almost uniformly become brown before they are discharged from the pycnidium. These spores are usually one-septate and many of them are constricted at the septum. They are also somewhat smaller in size than the pycnosporos of either of the other fungi discussed above. While some spores as long as  $26\mu$  are noted, in by far the largest number of specimens measured the spores were about 18 to  $23\mu$  in length by 8.5 to  $10\mu$  in width. This fungus was found on apple and hawthorn as well as ash, and careful comparison of it with *D. mutila* on the various hosts as well as in pure culture at various temperatures leaves no doubt that the two are distinct.

In attempting to select a name for this fungus, slides of numerous type and authentic specimens prepared during the past 15 years were re-examined. As will be evident from the partial synonymy given below, this fungus has been described under a variety of names, the oldest of which and the one which will be adopted here is *Diplodia sarmentorum* Fries. This species was described by Fries as *Sphaeria sarmentorum* in 1818 (2, p. 107) from material on *Menispermum canadense* in the Botanical Garden at Lund, Sweden. In his *Systema Mycologicum*, 1821, the species is listed with a description under the same name. In his *Summa Vegetabilium* he transferred the species to the genus *Diplodia* (page 417), at the same time indicating that he considered it identical with *D. mamillana*, which, however, proves on examination to be a quite different fungus. The fungus was distributed in his *Scleromyceti Sueciae* as No. 18 [not 28, as it is sometimes listed because of a defective type in the label].

There are three good specimens of this number in the Mycological Herbarium of the Bureau of Plant Industry, U. S. Department of Agriculture, one in the original set, one in the so-called Sbarbaro collection, and one in the Michener Herbarium. They are all alike and all show good spores. The packet in the Sbarbaro collection bears this comment in Fries' handwriting: "*Diplodia mamillana-sarmentorum* Fries Summa p. 417."

#### DISTRIBUTION OF *DIPLODIA SARMENTORUM*

Like *Diplodia mutila*, *D. sarmentorum* is relatively rare in the continental United States. Thus far the writer has seen only six

specimens, of which four, including the one described by Peck as *Diplodia Alni-rubrac*, were from the same region in which *D. mutila* is most commonly found, that is, the Northwestern States. Peck's specimen was collected on *Alnus rubra* at Rollingbay, Wash., by E. Bartholomew. The other specimens were on apple or pear from western Oregon.

*Diplodia sarmentorum*, however, appears to be common in Europe. The list of synonyms gives some idea of its distribution and host range. The writer has studied this species in cultures made from material collected by Fragoso at Madrid, Spain, in 1922 on *Alnus cordifolia*, *Genista tinctoria*, *Pyrus elcagnifolia*, and *Viburnum rugosum*, and on cultivated *Citrus* (both lemon and orange) and walnut bark from Acireale, Sicily, 1930 by Fawcett. The writer collected it in England on hawthorn and cultivated apple in both 1930 and 1935. On the whole, however, fungi of this group are by no means as plentiful in England as in the eastern United States. At least one important factor may be the scarcity of favorable substrata. As pointed out many years ago by Tulasne, these fungi are commonest on branches that have been cut from healthy trees and left for a period on the ground. Such prunings are abundant in the eastern United States but relatively rare in England, where prunings from fruit trees are usually burned and where there is very little indiscriminate cutting of healthy woody shoots.

DIPLODIA SARMENTORUM Fries, Summa Veg. 417. 1849.

Synonyms based on examination of type or authentic specimens.

*Sphaeria sarmentorum* Fries, Syst. Myc. II, 498. 1822.

*Diplodia macrostroma* Lév. Ann. Sci. Nat. III. 5: 291. 1846.

*Diplodia vulgaris* Lév. Ann. Sci. Nat. III. 5: 291. 1846.

*Diplodia salicina* Lév. Ann. Sci. Nat. III. 5: 292. 1846.

*Sphaeropsis depressa* Lév. Ann. Sci. Nat. III. 5: 295. 1846.

*Diplodia Siliquastri* West. Bull. Soc. Roy. Bot. Belg. 244. 1863.

*Diplodia Crataegi* West. Herb. Crypt. fasc. 25, No. 1128. 1859.

Kickx, J. Flore Crypt. Fland. 1: 393. 1867.

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- Diplodia Euonymi* West. Herb. Crypt. fasc. 19, No. 930. 1854.  
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*Diplodia inquinans* West. Herb. Crypt. fasc. 8, No. 371. 1849.  
Kickx, J. Flore Crypt. Fland. 1: 398. 1867.  
*Diplodia Crataegi* Fuckel, Symb. Myc. 393. 1869.  
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*Diplodia Humuli* Fuckel, Symb. Myc. 393. 1869.  
*Diplodia Tiliae* Fuckel, Symb. Myc. 394. 1869.  
*Diplodia malorum* Fuckel, Symb. Myc. 395. 1869.  
*Diplodia Alni* Fuckel, Symb. Myc. 395. 1869.  
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# UNIFORMITY AND STABILITY OF MYCOLOGICAL NOMEN- CLATURE <sup>1</sup>

C. L. SHEAR

We are sometimes inclined to become discouraged on account of the lack of progress being made in settling our nomenclatorial difficulties. We found some encouragement, however, in the fact that the mycologists of the 6th International Botanical Congress chose this subject for discussion; as it indicated that systematic mycologists of all countries were recognizing the fact that the conditions and problems met with in the nomenclature of the fungi are very different and much more complex than those met among the flowering plants, and therefore need special consideration. If uniformity and stability in the use of the names of fungi are to be attained, these differences must be recognized and plans formulated to meet the different conditions and problems.

So far as I am aware, no one denies at present the desirability of securing greater uniformity and stability for the generic and specific names of fungi, in so far as this is compatible with the true aims and purposes of systematic mycology.

The fundamental requirements of a satisfactory nomenclature are uniformity, stability, exact application, and convenience.

Before any successful plan for accomplishing these purposes can be made, however, we must have a full knowledge of the conditions and problems which confront us—and in order to understand these we must know the history, evolution, and course of development of the names and concepts prevailing at the present time.

The founding of genera and species of fungi in a broad application of these terms may, I think, be properly attributed to Micheli (7) who might be termed the "Father of Mycology." Some of our present generic names are still quite appropriately credited to

<sup>1</sup> Paper presented by invitation at the 6th International Botanical Congress, Amsterdam, Holland; Sept. 5th, 1935.

him. As to specific names, however, the polynomials used by him and his successors until the time of Linneaus, and even later by Haller and others, were entirely impracticable for general purposes and had to be abandoned.

The development of a true concept of genera and species of fungi as natural groups was necessarily slow on account of the lack of methods and facilities for obtaining exact knowledge of such plants. With the development of the microscope and an increase in the number of students, more definite knowledge was obtained in regard to the characters and general limitations of genera and species. Progress, however, was slow, and even at the time of the publication of Fries' *Systema* (4), 1821-1832, which the priorists regard as the best starting point for most of the fungi, the so-called genera were mostly not natural divisions, but heterogeneous groups of species of very different generic affiliations. The lack of exact knowledge of these plants, especially the micro-fungi, on account of their small size and pleomorphic life histories, has made the segregation and definition of natural groups a very slow and difficult process; so that even today there are great numbers of genera and species named whose exact definition and limitation are impossible. Under such conditions it should be evident that it is extremely difficult to say just when any particular generic or specific name was validly published, and real priority established. According to the 1930 International Rules, Sec. 3, Art. 19: "A name of a taxonomic group has no status under the Rules and has no claim to recognition by botanists, unless it is validly published." Unfortunately, the Rules do not give a very good positive definition of valid publication, but Art. 37 (2) says: "A name is not validly published unless accompanied by a description of a group or by a reference to a previously and effectively published description of it.

Under rejection of names, Sect. 12, there are three articles, 62, 63, and 64, under any of which many of our old fungous names become invalid. Art. 62 says: "A name of a taxonomic group must be rejected if, owing to its use with different meanings, it becomes a permanent source of confusion or error." Art. 63 says: "A name of a taxonomic group must be rejected when its application is uncertain." And Art. 64 reads: "A name of a

taxonomic group must be rejected if the characters of that group were derived from two or more entirely discordant elements."

It seems clear from these quotations that a great many of our best known fungous names are invalid as originally proposed. Thus we must decide whether to discard all the names of genera and species insufficiently described and including heterogeneous groups or validate them at the time they were first satisfactorily described and segregated. In either case the difficulties are so great that no uniform or satisfactory decisions could be made on a priority basis and the result would be more change and confusion of names instead of stability.

In order to emphasize this difficulty more clearly and forcibly, it may be well to call attention to a few specific cases which are more or less typical of hundreds of others. Take, for example, the genus *Dothidea*. The name was first published by Fries (2) in 1818, with the following description:

"DOTHIDEA, Fr.

"Tab. V. f. 4, 5.

"*Receptaculum* nullum. *Perithecia* difformia, tuberculoso-corrugata, intus solida, humectata nulliuscula, ostiolo nullo."

Brief diagnoses of five species are added. The first, *D. conspersa* (Tode), according to Rehm, is *Tympanus conspersa* Fries; but Fries did not regard this as typical of the genus as he adds: "Heteroclita species." Most of the other species are doubtful and none is to be found in *Dothidea* as now applied.

The next year, 1819, Fries (3, p. 87) redescribed the genus and included seven species and two varieties, discarding two from his previous list and adding four, thus complicating rather than clarifying the situation. His next treatment of it was in 1823 (4, vol. 2: 548-65). Here he enlarged the genus still further, referring to it 54 species separated into four divisions. Among the species in this heterogeneous collection were plants which at present are scattered through a dozen or more different genera belonging to different families of Discomycetes, Pyrenomycetes and Imperfecti. Could one by any stretch of the imagination at present regard this *omnium-gatherum* as a genus? Our late French colleague, Che-

nantais, would have called it "un gâchis," which in colloquial English would be a "mess" or "Mischgattung" of German mycologists.

Again, in 1825, Fries (5, p. 112) treats *Dothidea*, modifying his previous descriptions somewhat but mentioning no species; simply citing "Syst. Myc. 2: 548," and remarking that the genus is natural but very difficult to define. His next and last treatment in 1849 is confined to a catalogue of Scandinavian species (6, p. 386) including 24 as genuine members and 4 as uncertain. He begins the list with the section "erumpentes" and names first *D. ribesia*, *D. Berberidis* and *D. Sambuci*. The inclusion of these three species, one of which, *D. Berberidis*, he had not before put in the genus, and their position at the head of the list, is apparently due to the work of DeNotaris eight years earlier.

Little was known about the microscopic characters of any of these plants, especially the asci and spores until DeNotaris (8, p. 65) gave a detailed description and good illustrations of *D. Sambuci* var. *Hederac* and *D. Berberidis*. In 1849, in the same series of papers, he described and illustrated in detail *D. ribesia* and stated that previous descriptions of this species by Nees, Chevalier, and Rebentish were very incomplete and unsatisfactory. He says the genuine species of *Dothidea* are the three just mentioned, and the others included by Fries should be excluded so far as he had been able to examine them.

Here I think we may say that the genus *Dothidea* was first really established or "validly published" according to the Rules. The three species referred to above were included in it by nearly all subsequent authors, including Tulasne, who gives a detailed description with illustrations of the life history of *D. ribesia*.

Winter in 1887 restricted the application of the name chiefly to the species mentioned by DeNotaris, including hyaline as well as colored ascospores. In the meantime many of the species of Fries had been transferred to other genera. Saccardo (9) took *D. Sambuci* which has colored spores as his first species and referred *ribesia* and *Berberidis* to *Plowrightia*, because he believed the spores in those species to be hyaline or only slightly greenish. Whether there are any real generic differences between *D. ribesia* and *D. Sambuci* remains to be determined by further studies of their life

histories and conidial stages. The general usage of mycologists throughout the world since DeNotaris has been to regard *D. Sambuci*, at least, as a typical member of this genus.

In 1915, Theissen and Sydow (18, p. 328) discussed the genus, pointing out what a very heterogeneous group of species Fries had included, and decided to select as the type *D. moriformis* (Ach.) Fries, the first species mentioned by Fries in 1823. Since the identity of this species is doubtful and since so many species had been added to the genus which were not congeneric with *D. Sambuci*, they decided that the name *Dothidea* should be discarded entirely, and the group typified by *D. Sambuci* should have a new name, *Systemma*, and *D. ribesia* and *D. Berberidis* should be put in *Dothidella*. Thus an attempt to follow the rules as they stood at that time results in the proposal to discard one of the oldest and best known generic names among the Dothidiales and the one on which both the family and order were based, because the first species listed by Fries in the place cited happened to be uncertain. Clements and Shear (1) in 1931, selected *D. Sambuci* as the type of this genus, in accordance with the recommendation of the Cambridge revision of the International Code, which would permanently establish it in the sense in which it has been generally used for nearly one hundred years.

The history of *Dothidea* in its general aspects is very similar to that of hundreds of generic names found among the Ascomycetes as well as other groups. A few other changes of names which would be required on a priority basis are as follows:

*Amphisphaeria* Ces. & DeNot. 1863 would become *Sphaeropsis*  
Lév. 1842

*Cordyceps* Fries 1849 would become *Corynesphaera* Dumort.  
1822

*Daldinia* Ces. & DeNot. 1863 would become *Peripherostoma*  
Gray 1821

*Linospora* Fuckel 1869 would become *Phoma* Fries 1823

*Nectria* Fries 1825 would become *Hydropisphaera* Dumort.  
1822

*Valsa* Fries 1825 would become *Syphosphaera* Dumort. 1822.

In discussions of some of these names in earlier publications (1, 2, 4, 7) we have given different synonyms for some of them as Linnaeus instead of Fries was taken as the starting point. What the synonymy would be and what changes would be required by the application of the priority rules in the case of genera containing heterogeneous species depends chiefly on the choice of the type or standard species for each genus. It would seem clear from the case of *Dothidea* just described that the selection of the type of a genus is of far greater importance in preserving our old and well established names and insuring their stability, than the question of priority of publication. It would also seem self-evident that the method followed by Theissen and Sydow in the case just described will not give us the stability and uniformity of names, which has been the avowed purpose of all laws, codes, and rules since the first Botanical Congress in Paris in 1867. The plan to fix names according to priority or according to typification based on the first species described or mentioned can only bring about great change and confusion in the use of names and serve no useful purpose. As to priority, how can one determine when a genus such as *Dothidea* was really validly established? The early descriptions were not sufficiently detailed or accurate to make identification possible and the species included were also frequently very doubtful. As a matter of fact, in the case of *Dothidea*, the genus was not really established until DeNotaris gave his detailed description and illustrations; so one might claim that he was the real author of the genus. This shows how impracticable either of the proposed plans, priority of publication or typification by first species, is; if we regard the chief aim and purpose of rules to be the attainment of uniformity and stability in the use of names with the least change and inconvenience possible. It would therefore seem clear that generic names must be fixed on a type basis selecting such types as will fix names according to their present usage so far as possible.

The most important need at present, therefore, is the adoption of a practical plan to preserve our present names and give them a definite and fixed status within a reasonable period of time. The writer believes such a plan is available. The phanerogamic botanists have attempted to establish names on the basis of priority

of publication, realizing that the plan would bring about many changes in current usage, but hoping eventually to secure stability. Ethical considerations have also been urged in support of the priority plan; it being contended that great injustice would be done to the oldest author of a plant name if his name were not adopted and he given credit for it. While we believe that proper credit is due the early botanists who made important contributions to systematic botany, yet abundant recognition and honor can be bestowed upon the deserving without entailing so much trouble and inconvenience to the great number of people who today have to use technical plant names, as the application of the priority rule would entail. It would seem to be much more in harmony with high ideals of justice and ethics to credit the authors who first adequately described, illustrated, and preserved specimens of the plants named. Past experience has already demonstrated the impracticability of the priority method to attain the desired end, even with the flowering plants. As for fungous names, we should be very thankful that no general attempt has yet been made to apply the priority plan, as very few of our most familiar names would have been left. For further discussion of this phase of the subject we would refer to previous papers by the writer which are listed at the end.

Before there can be any stability of generic names, however, those applied to genera containing two or more heterogeneous species must be fixed to some particular species which shall be held as the nomenclatorial type or standard species. The type method of fixing generic and specific names was proposed by American botanists in their efforts to fix the application of such names. This plan offers the simplest and most practical method of definitely fixing the application of a generic name to at least one species which shall be the basis for the generic description and concept, and about which other con-generic species may be grouped.

Owing to a lack of understanding of the conditions involved and the results which would follow, the first plans for selecting types were unfortunate. The selection of the first species listed under a genus seemed very simple and easy of application; but



when applied to heterogeneous genera frequently resulted in the application of a name to a group entirely different from that to which it is now generally applied. The case of *Dothidea* which we have described is an excellent example. It was next suggested that many of the unfortunate changes which would be caused by the first species plan would be avoided by selecting the best known or an economic species, if such happened to be included in the original list. This was a great improvement so far as the flowering plants were concerned, but does not meet the needs of mycology. Fortunately, the recommendation for selecting types of genera of non-vascular cryptogams, as adopted in the 1930 rules of the International Congress at Cambridge, if followed, will make it possible to fix our present generic names of fungi in such manner as to reduce further changes of names and their application to a minimum. The recommendation is as follows:

Section 2, Art. 18, Recommendation 6: "In selecting a nomenclatorial type of a genus of non-vascular Cryptogams, botanists should, where possible, choose a species that will fix the generic name as it is now commonly applied."

Article 5 covers this in a more general way "In the absence of a relevant rule or where the consequences of rules are doubtful, established custom must be followed."

An attempt to carry out this plan was made by Clements and Shear (1) in 1931. It is perhaps needless to say that many unfortunate choices of types were made. These may be easily changed. The practicability of the plan, however, was demonstrated. What is now needed is the appointment of a standing committee of international systematic mycologists most familiar with the nomenclature of the major groups of fungi and who are in sympathy with this plan, to prepare a list of accepted genera typified according to the method recommended in the code as already cited.

By the above method of selecting types of genera, supplemented when necessary by resort to the list of *nomina conservanda*, it will be possible to preserve practically all of the names at present in common use except for such changes as may be necessitated by revision of generic concepts and limitations due to lack of knowl-

edge of the species and their relationships and to differences of opinion of monographers.

To summarize briefly: To stabilize present generic and specific names and definitely fix their application are the greatest needs of systematic mycology.

Generic definitions and concepts among the fungi have developed gradually as our knowledge has increased and though a generic name may have been proposed at an early date in many cases no adequate generic description or concept was attached to it until a much later date, making it very difficult to say at what date it was "validly published."

It has been demonstrated that stability and uniformity can not be attained by the application of the priority of publication plan, but can be accomplished to a great degree by the selection of such type species and specimens as will fix the names as they are generally applied at present.

The subject has been further discussed in a previous series of papers cited (1: p. 14-15, 10-17) in the bibliography appended.

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# BASIDIAL PROLIFERATION THROUGH CLAMP-FORMATION IN A NEW SEBACINA<sup>1</sup>

DONALD P. ROGERS<sup>2</sup>

(WITH 34 FIGURES)

The classical studies of the clamp-connections of basidiomycete hyphae by Kniep (10) and Bensaude (1) and the recent illuminating discussion by Martens (12) provide an essentially complete basis in observation and hypothesis for the interpretation of these structures. The cytological phenomena involved in the formation of the clamp-cell were first described by Kniep; and upon a comparison of the clamp as he had observed it with the crozier of *Pyronema* as described by Claussen (4) he established the homology of the two structures. Bensaude, whose single-spore cultures of hymenomycetes demonstrated the genetic dissimilarity between the nuclei whose conjugate division is associated with clamp-formation, discovered the actual functional significance of the clamp: that is, it is an organ insuring that each of the hyphal cells between which it lies shall possess not sister nuclei, but a dikaryon of complementary members, one nucleus being descended from either member of the parent dikaryon. Martens undertook to push the phylogenetic problem back to the rise of the crozier. He pointed out that even in crozier-bearing species of Ascomycetes conjugate division occurs within the basal, broader portions of the ascogenous system without formation of such a special structure, croziers usually being present only where the hyphae are too narrow to contain two nuclei, or two spindles, placed side by side.<sup>3</sup> In a primitive form in which the crozier had not yet been evolved, he pointed out, simultaneous division of paired nuclei in such a narrow portion of the ascogenous

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 142.

<sup>2</sup> National Research Fellow.

<sup>3</sup> Cf. Martens (12), pp. 270-273, and especially footnote 1, p. 273.

system would take place with the spindles lying longitudinally and one above the other, and would result in the formation of a series composed of two sister nuclei lying above two sister nuclei. Only the second and third nuclei of such a series would be adjacent and complementary, and this median pair would subsequently be walled off together, by septa formed across the mitotic spindles, leaving the basal and apical nuclei isolated.<sup>4</sup> Asymmetric growth of the median cell as it enlarged to form an ascus might well, however, thrust the uninucleate apical cell aside, to the degree that fusion with the basal cell could take place; such fusion would be the expected result of the mutual affinity of the isolated nuclei. Thus a crozier would be completed. Martens finally maintained that by precocity in membrane development the curvature which primitively occurred *after* conjugate division came to occur before<sup>5</sup>; and that by extension of this tendency in membrane development apical elongation of the hypha beyond the region of recurvature similarly took place before division, bringing about the lateral origin of the clamp-beak of basidiomycete hyphae. It may be noted that such ontogenetic anticipation, such development of a cell-membrane in advance of the nuclear development which makes it appropriate, is not unknown elsewhere; as an example, epibasidia often are budded out by the hypobasidium before division of the diploid nucleus, or after its first division, in *Tulasnella* and in various genera of the Tremellaceae.<sup>6</sup> By this hypothesis, which rests on familiar processes, Martens gave causal intelligibility to a course of development previously only teliologically comprehensible. The theoretic interpretation thus completed is nevertheless based, so far

<sup>4</sup> "This is exactly the arrangement encountered by Guillermond (Ann. Myc. 3: 347, fig. 86-91) in *Peziza Catinus*."—Martens.

<sup>5</sup> In *Humaria rutilans*, according to Gwynne-Vaughan (7), curvature may occur either before or after conjugate division. The croziers of this species (7, fig. 8-11) are figured as being less specialized, more clearly representing recurved hyphae, than those of *Pyronema*, and may well be taken to exemplify the earliest stage in the evolutionary process described by Martens. The figures may, however, represent only the recurved ends of the early ascogenous processes (Gwynne-Vaughan & Williamson (9), p. 363, and fig. 31-35, 37-39; Claussen (4), fig. 35-39, 54, 55), which are not, according to these authors and the observations of the writer, definitive croziers, but structures giving rise to croziers.

<sup>6</sup> Rogers (15), p. 92, fig. 5, 20-22; Whelden (18), p. 423; (19), p. 52; (20), p. 509; (21), p. 125.

as the Basidiomycetes are concerned, on study of the clamp-connection only as a component of the hyphal system.

In his detailed consideration of the ascogenous hyphae of *Pyronema*, Claussen wrote: "As a result of the development of croziers and the accompanying nuclear- and cell-divisions, two nuclei of unlike sex always remain in reserve in stalk and beak for the formation of additional asci." Primarily, just this is the result accomplished by the crozier, however the course of its development be regarded: whether it be interpreted teliologically, as a single process—which it assuredly now is—or more rationally, as a series of processes, the curvature and fusion being taken to be "purely corrective" (12) of a division after which one of each pair of daughter nuclei has been left isolated. Conceivably the Ascomycetes are descended from ancestors in which karyogamy was invariably followed by meiosis and spore formation (cf. Darlington (6)); in any event, all developments beyond the simplest imaginable ascogenous system, either through increase in number of nuclei or through complexity of branching, may be taken to be associated with augmentation of the number of asci resulting from a single cytogamy; Claussen's phrase "remain in reserve for the formation of additional asci" is thus justified. Furthermore, Claussen's dictum as to the function of the crozier, like Martens's hypothesis as to its origin, is applicable whether or not in any particular form the paired nuclei can be shown to be genetically different. It seems likely that primitively complementary pairs were present, as they surely now are in some forms (e.g., *Neurospora tetrasperma* (5)), although in homothallic species this need not be the case; nor would the paired nuclei be sexually differentiated if they were already diploid. But Gwynne-Vaughan & Williamson have pointed out (9, pp. 363, 364) that the observed arrangement of nuclei in the crozier could be brought about by a tendency to form septa across the spindles of the conjugately dividing nuclei. By this means a single nucleus would be isolated in the beak and another in the stalk quite as well as by association of a median complementary pair. And since two nuclei from the ascogenous hyphae, be they haploid or diploid, are necessary to the formation of one ascus, the "reserve" must still be of biological advantage to the organism.

The operation of the crozier-mechanism in the multiplication of dikaryons is then, both from observation and by hypothesis, connected primarily with the multiplication of gonotoconts. If the clamp be the homologue of the crozier, as on the hypothesis already summarized, then it is to be inferred that the clamp may similarly be associated with the multiplication of gonotoconts. That such is actually the case has been mentioned by Kniep (10, p. 392) and Bensaude (1, p. 121). Such association of the clamp-apparatus with basidial proliferation is reported by Brefeld (2) in *Phleogena* (*Pilacre Petersii*) and by Kniep (10) in what is probably *Corticium coronilla* (*C. varians* Kniep), in *Hypholoma fasciculare*, and in *Agaricus* sp. According to the writer's observations it occurs also in *Tulasnella rutilans*, in *Gloeotulasnella traumatica*, in *Mytillopsis Langloisii* of the Auriculariaceae, and in *Peniophora aurantiaca*; it is unquestionably discoverable by special search in many other fungi. Thus far, however, no study of this aspect of the clamp mechanism has appeared. In view of the fact that such objection to the homology of clamp and crozier as appears seems to arise in part out of a rather hazy general notion that the crozier is a "reproductive" structure while the clamp is "vegetative," such a study appears to be desirable.

Living material of a fungus in which in the hymenium the clamp serves exclusively and conspicuously in the direct proliferation of basidia recently came to hand; the present account is based on study of this material. The fungus being an undescribed species, a diagnosis of it is first presented.

#### DESCRIPTION OF SPECIES

##### ***Sebacina prolifera* sp. nov.<sup>7</sup>**

Fructification effused, very thin, when fresh mucous-gelatinous, hyaline, when dry nearly or quite evanescent, perceptible only under the lens, as an interrupted colorless varnish-like incrustation;

<sup>7</sup>Fructificatio resupinata, mucoso-gelatinosa, tenuissima, hyalina, sicca evanida; hyphae laxae intertextae, conglutinatae, nodoso-septatae, 1.5-2.5  $\mu$  diametro; basidia in cellula clavata gesta, per ansam anastomosis basalem prolifera, primum globosa, maturitate pyriformia vel oblonga, cruciata-septata, 10-14  $\times$  8-9  $\mu$ , epibasidia 4 crassa, 2-3  $\mu$  diam., usque ad 20  $\mu$  longitudine, ferentia; sporae subcylindratae, utrinque leviter attenuatae, arcuatae, 18-20  $\times$  3.5-4  $\mu$ , per repetitionem germinantes.

in section  $15-60\ \mu$  thick, composed of an ill-defined subicular layer of interwoven hyphae, thin-walled,  $1.5-2.5\ \mu$  thick, with clamps at all septa, embedded in a gelatinous matrix, and supporting a fairly even hymenium; basidia borne on erect stalks slender at the base and expanded at the basidium, with stalk and basidium connected by a large clamp, trumpet-shaped, broadened apically, on which is borne a second basidium; probasidia subglobose, becoming elongate; hypobasidia oblong to pyriform,  $10-14 \times 8-9\ \mu$ , cruciate-septate, bearing 4 epibasidia  $2-3\ \mu$  thick, up to  $20\ \mu$  long; spores subcylindric, slightly attenuated at either end, blunt, curved,  $18-20 \times 3.5-4\ \mu$ , germinating by repetition.

On lower side of a sodden, well-rotted, decorticate log of *Ulmus* sp., lying on the ground, Linder's Woods, Iowa City, Iowa, III. 20. 1935, *D. P. Rogers 80*, type. Type deposited in the author's herbarium, the mycological herbarium of the University of Iowa, the Farlow Herbarium, the U. S. National Herbarium, and the herbarium of the Royal Botanic Gardens at Kew.

*S. prolifera* belongs among the delicate gelatinous members of the genus, near *S. fugacissima* and *S. calospora*. It differs from all species of *Sebacina* known to the author in the broadened sub-basidial cell and the trumpet-shaped clamp by which basidia proliferate, and also by the slender-cylindric, blunt spores. In the latter character it somewhat resembles *S. calospora*, where the spores are, however, more slender and more attenuate.

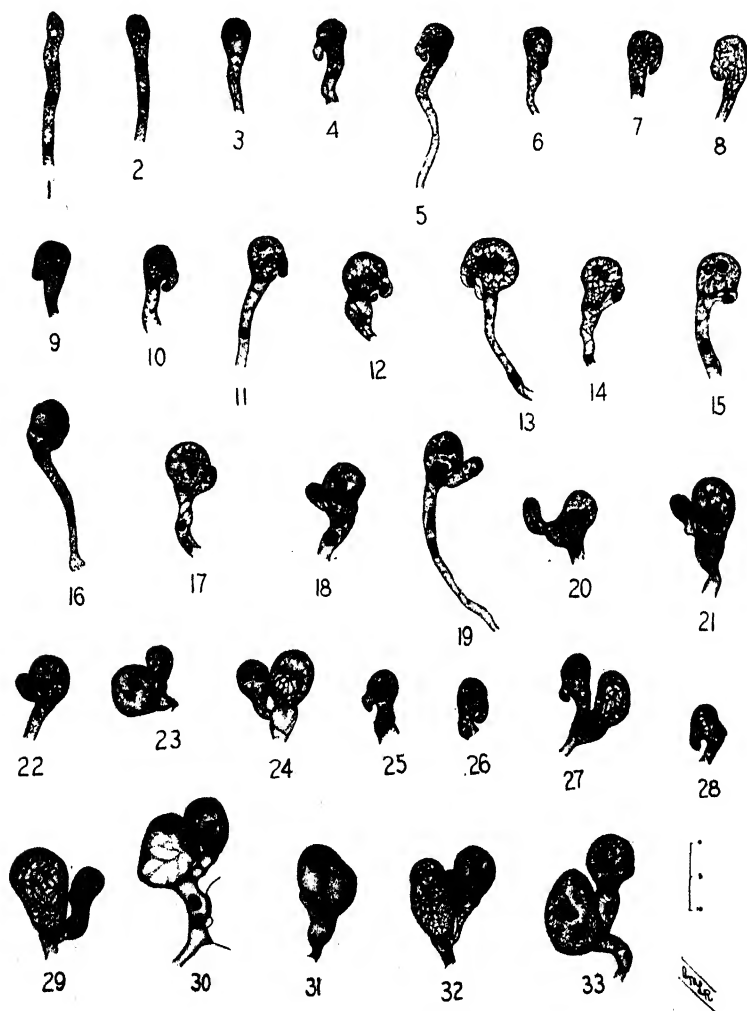
#### METHODS

For preliminary examination of *Sebacina prolifera*, material was crushed beneath the cover-slip in a solution of KOH and phloxine, as recommended by Martin (13); the taxonomic description was drawn up from such preparations. More critical examination appearing desirable, portions of the fruiting-layer adhering to flakes of the substratum were fixed in Flemming's weaker solution and embedded in paraffin. Of this material sections were cut at  $12$ ,  $5$ , and  $3\ \mu$ , stained in iron-alum haematoxylin, destained in picric acid, and counterstained in phloxine. Only in the  $12\ \mu$  sections were the relations of the various hymenial elements favorably shown; the account that follows was drawn from study of such preparations.



## OBSERVATIONS

The thin basal layer of the fructification of *S. prolifera* is made up of slender clamp-bearing hyphae, loosely interwoven, running



FIGS. 1-33. *Sebacia*.

along the substratum or diagonally away from it, and held together by a gelatinous matrix. From these subicular hyphae arise perpendicular branches, of somewhat greater diameter, which become distally clavate as they approach the surface of the hymenium. A

branch of this sort, the primordium from which a basidium and its stalk are to be differentiated, is usually without septa and contains a single dikaryon which lags considerably behind the apex of the cell (FIG. 1). With further growth the primordium becomes abruptly expanded near the tip and the nuclei move to a subapical position (FIG. 2, 3). From one side of the inflated end, just below the widest part, is put out a sharply recurved beak; at the same time the end swells out laterally so as to lie about equally beyond beak and stalk (FIG. 4). Subsequently one nucleus migrates to a position above the base of the beak (FIG. 5). The nuclei now undergo conjugate division, the one spindle lying partly in the beak, the other well against the opposite wall (FIG. 6). The basal daughter nucleus of this second division-figure immediately moves down into the stalk (FIG. 7, 8); nuclear reorganization takes place apparently almost at once (FIG. 9), and septa are formed separating from stalk and beak the young basidium with its dikaryon (FIG. 10).

The completion of the clamp clearly is brought about essentially as Buller (3) has described it in various hyphae, by "hook-to-peg," and not hook-to-side, fusion. The stalk puts out from just below its distal cross-wall a short, very slender outgrowth (FIG. 11-12), which comes in contact with the comparatively passive tip of the beak and fuses with it, the lumina becoming continuous (FIG. 13, 14), and the beak nucleus moving into the stalk (FIG. 15, 16). If the young basidium has enlarged little beyond its condition at the time of formation of the beak, the clamp-cell may be all but appressed to the wall of the basidium (FIG. 11, 14); if considerable growth has meanwhile occurred, the outgrowth from the stalk may become conspicuously peg-like before reaching the beak (FIG. 12, 13). After completion of the clamp the nuclei from stalk and beak come to lie together some distance from the apical end of the cell (FIG. 17).

The primordium has at this stage developed into a long stalk, tubular at the base, considerably broadened at the summit, a more or less globoid probasidium, and a connecting clamp, very slender at the base, flaring towards its union with the basidium (FIG. 17). Further development of the stalk-cell dikaryon is not perceptibly coördinated with the nuclear or morphologic development of the

basidium. The apical, outer wall of the clamp, usually close beside the probasidium, commences to swell so that the enlargement soon involves the whole upper part of what was the beak (FIG. 18). Enlargement may be about the same in all directions, and result in a globoid body lying close against the basidium (FIG. 21, 22), or apical elongation may occur, so that a clavate appendage appears, seated on the clamp (FIG. 19, 20). After the swelling is well under way, the nuclei of the stalk move through the clamp into the swollen portion (FIG. 22, 23), and a structure is formed beside the already differentiated probasidium (FIG. 24) essentially the same as an early stage of the primordium (FIG. 3).

In this secondary primordium the entire process occurring in the primary is repeated—pushing out of a beak, conjugate division, cutting off of the binucleate probasidium, fusion of beak and (secondary) stalk, reconstitution of a dikaryon from beak and stalk nuclei (FIG. 25–30); the stages are so far identical that it is frequently difficult or impossible, because of loss of basal attachments in sectioning, to determine whether structures observed belong to primary or later clamps. The stalk of the second basidium is continuous with that of the first, and the basally migrating dikaryon moves far down in the primary stalk (FIG. 30). After a varying interval the second clamp develops a third basidium and stalk (FIG. 31–33); and so on: groups of four or five basidia, each formed from the clamp of the next larger, are frequently intact in  $12\mu$  sections, and even as many as six or seven have been observed (FIG. 34 a), the oldest so far disintegrated as to be scarcely perceptible. There is reason to suppose, from the thickness of the hymenial layer in some parts, that even larger numbers of basidia are produced upon a single fertile hypha. All principal stages in the growth of the basidia occur in the preparations examined. Since they agree in all essential points with the course of development already established for the tremellaceous basidium, description here is superfluous.

#### DISCUSSION

The clamp mechanism here described may well be compared, as was the hyphal clamp, in the work of Kniep and Bensaude, with the similar mechanism of the most completely known ascomy-

cete diplophase, that of *Pyronema confluens*. It is shown by Claussen's observations that a clamp—that is to say, a completed crozier—once having been formed, there are two ways in which the cells which it unites may continue the multiplication of cells and dikaryons. These are, quite simply, (1) by division of the terminal cell with its dikaryon, and (2) by division of the basal. The first typically occurs through elongation of the terminal cell and formation at its summit of a second crozier; by this process a crozier-upon-crozier series can be built up.<sup>8</sup> In material of *Pyronema* examined by the writer this first type of development is much the commoner of the two in the early stages of the ascogenous hyphae. According to the second, either the first-formed crozier or the side of the basal cell puts out a protuberance upon which a second crozier is formed; by this process, in its simplest manifestation, a cluster of binucleate cells is built up arranged as a strict unilateral cyme, each terminal cell having a clamp at its base, and the lumina of the basal cells being continuous with each other.<sup>9</sup> This type predominates in later development. But most commonly, any considerable part of a hyphal system is a combination of the two. In another way, also, the ascogenous hyphae in question are not conformable to a single pattern; for although cell-multiplication here is by hypothesis essentially multiplication of potential gonotoconts, not all the cells and dikaryons produced develop into asci; by sterilization a considerable portion is retained as merely structural elements: conducting and supporting cells; "vegetative" cells.

On the first, the crozier-on-crozier, scheme of development are based all comparisons of the clamp-hyphae of Basidiomycetes with crozier-bearing ascogenous hyphae, and all arguments for the homology of the two systems. The terminal basidium corresponds to the ascus which sooner or later puts an end to the growth of such a series of croziers; increasing sterilization of the basal segments, and increasing development of the basidiomycete diplophase as an assimilative and structural system, can account for such differences as appear in the basal portion. With the second, the cymose, scheme of development, basidial proliferation directly

<sup>8</sup> Cf. Claussen (4), fig. 70, left branch.

<sup>9</sup> Cf. Claussen, fig. 75, right branch.

through clamp-formation, such as occurs in the fungus here described, is as certainly, and much more obviously, homologous.

Not only the relations, but also the forms, of the comparable bodies in ascomycete and basidiomycete may be strikingly similar: for example, the beak as it first appears in *Sebacinia prolifera* would seem to be almost as much a terminal recurvature, and as little a lateral branch, as the earliest hook in *Pyronema*.<sup>10</sup> Examination by the writer of stained material of *Pyronema* and *Ascocorticium* in which young croziers were present bears out this statement. The comparison can be carried through the complete series of stages: for example, fig. 4, 5 of this paper and Claussen's figure 76 (right), 6 and 52, 10 and 56 (right), 16 and 60, 30 and 65, 22 and 58, 20 and 59, 27 and 68 (left), 33 and 75 (right). Those who accept the homology between crozier and clamp have always held that such differences as appear are adventitious, a matter of proportion; here this difference in proportion is perhaps minimal. On the other hand, those who do not recognize the homology under discussion have chiefly considered in the Ascomycetes the cymose type of cell-multiplication, overlooking the fact that the cell-complex in either group is a mixture of the two types, and that among the Basidiomycetes the formation of basidium-bearing branches, or especially of basidia, from cells below the terminal one is always an example of the second type of development.

Objection has been made in two recent works to the homologizing of clamp and crozier. Gwynne-Vaughan & Barnes (8) recorded the observation that the clamp is lateral and the crozier terminal; as a matter of observation this is true. So far as the work in question is concerned, no application is made of this assertion, and no suggestion of a mode of origin of the clamp is offered. Buller (3) held that "the clamp-connexion may be regarded as a means for providing between any two adjacent cells of a diploid mycelium two septa instead of one and, therefore, two passage-ways [pores in the septa] for the streaming of protoplasm instead of one," while "the hook may be regarded as a means for

<sup>10</sup> Bensaude (1, p. 120) has noted a like similarity. The difference between *Pyronema* and *S. prolifera* would seem to be much less than that between the crozier described for *Humaria* (7, fig. 8, 9, 11) and that of *Pyronema* (4, fig. 45, 52; 9, fig. 46-49). But cf. footnote 5.

constructing numerous ascus cells." Martin (14) has already recorded an objection to the bases for this distinction. The case for the functioning of septal pores in translocation is clear enough, but scarcely explains the appearance of a clamp-cell; like Buller's conjecture as to the reason for backward curvature of the beak (3, pp. 43-48), it is undisguised teliology. The answers to Buller's reasons for denial of the homology of crozier and clamp are already present in principle in Kniep, Bensaude, and Martens: briefly, he has over-

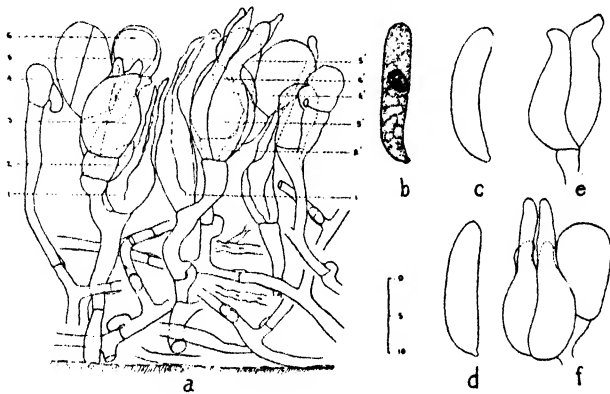


FIG. 34. *Sebacina*.

looked the crozier-upon-crozier series in the Ascomycetes and the cymose series in the Basidiomycetes, and also the biological difference between the diplophases of the two classes of fungi. The means afforded by *Sebacina prolifera* for refutation of his arguments are not more decisive, but only more obvious, than those of the authors mentioned. Buller has published four such arguments:

- (1) Whereas clamp-connexions occur in series along the hyphae of a vegetative mycelium, hooks occur not in a vegetative mycelium but in the terminal branches of ascogenous hyphae;
- (2) Whereas a clamp-connexion is formed in the middle of a terminal cell of a hypha, a hook is formed at the extreme end of a terminal cell of a hypha;

- (3) Whereas in a clamp-connexion the cell in which a single nucleus is temporarily imprisoned is formed from a lateral branch of a main hypha, in a hook the corresponding cell is cut off from the end of the main hypha after this has become bent backwards at the apex; and
- (4) Whereas clamp-connexions connect two successive cells and, as a rule, are not points of departure for new lateral branches, the end-cell of each hook, after fusion with the third cell from the end of the hypha, immediately grows forward to form a new very short branch which in turn soon becomes hooked at its apex.

Now not one of these contrasts presents any obstacle to the homologizing of the structures in question; for (1) the clamp-mycelium is not a purely "vegetative mycelium," but, like the ascogenous hyphae, the bearer of gonotoconts as well; (2) in the basidial primordia of *Sebacia prolifera* the clamp-connection is not formed "in the middle of a terminal cell," but in the same position as is the crozier of *Pyronema* and *Ascocorticium*; and where the difference does exist, it is accounted for by Martens's hypothesis; (3) the beak described in *S. prolifera* is as little a "lateral branch" and as much "the end of the main hypha . . . bent backwards" as the crozier of *Pyronema*; furthermore, in a discussion of comparative morphology such as this the question of lateral or terminal origin may be precisely the subject of the enquiry, a question to be settled by comparative morphology; whether the binucleate cell from which ascus or basidium may develop is the apex of the hypha or the apex of an angle in the hypha is the point at issue; to call the clamp-beak "lateral" in such a discussion is a begging of the question<sup>11</sup>; and (4) clamp-connections and croziers both invariably connect successive cells; both are frequently, but not invariably, points of departure for lateral branches<sup>12</sup>; the clamp described in *S. prolifera* and some croziers proliferate from the beak-cell in the same fashion; other clamps and other croziers do

<sup>11</sup> The case is comparable to questions arising in study of the morphology of spermatophyte inflorescences.

<sup>12</sup> Cf. Bensaude (1), p. 85, fig. 18; Kniep (10), p. 383, text-fig. 9, 10, and the examples there cited by Kniep; also (11), p. 86, text-fig. 2.

not do so, proliferation being from the binucleate cell beyond the beak; still others proliferate from the stipe.

This statement at great length of an argument that must be fairly obvious has been presented only because the somewhat more elliptical discussions of the authors of the hypotheses here defended have resulted in some cases in incomplete understanding of the grounds of their argument. It is quite clear that nothing fundamental has been added to these hypotheses; that the significance of the phenomena here reported in *Sebacina prolifera* lies not in any contribution which these phenomena can make to an already essentially complete interpretation, but in exemplification of the association of the structure in question—call it clamp or crozier—in the derived group of the Basidiomycetes with its primitive function; for here, too, it serves to increase indefinitely the number of dikaryotic cells from which may be formed gonotoconts. Therefore in a largely non-reproductive hyphal system the reproductive function of the clamp-connection persists.

The hypothesis of the derivation of the clamp from the crozier is capable of one application of which little has been made: not only must the Basidiomycetes have arisen from the Ascomycetes, and from ascomycetous forms in which the ascogenous hyphae possessed croziers, but the ancestral basidiomycete group must have been one of which at least some members possessed clamps. Now all families of the lower Hymenomycetes have members whose mycelium is clamp-bearing; clamps occur in all major groups of the Homobasidiomycetes and in the smuts. Of the rusts alone no species<sup>13</sup> is known to have clamp mycelium. Due recognition being given the fact that an organism may be primitive in one respect and advanced in another, this deficiency even so is held by the author to support his ruling out of the Uredinales as possible ancestors for the remaining Basidiomycetes (16). This is the conclusion to which existing evidence may be taken to lead. In the not entirely improbable event that clamps are demonstrated in a member of the Uredinales, it may well be that the anomalous clamp-bearing rust will be the exception which tests the rival theories of the origin of the group.

<sup>13</sup> Disregarding the highly unconvincing figures of Voss (17).



## SUMMARY

In *Sebacina prolifera* conjugate nuclear division at the apex of a fertile hypha is accompanied by clamp-formation. The dikaryon reconstituted in the basidial stalk by this process moves out into the enlarged clamp and there undergoes conjugate division, with the formation of a second clamp. The binucleate apical cells thus formed develop into basidia, the second basidium being borne on the clamp at the base of the first. By repetition of the process a unilaterally cymose cluster of basidia is formed. Thus among the Basidiomycetes the clamp may function in the development upon a single cell of an indefinitely large group of gonotoconts exactly as does the crozier among the Ascomycetes. This phenomenon affords additional confirmatory evidence for the hypothesis of the homology of clamp and crozier and for the derivation of Basidiomycetes from Ascomycetes. A corollary of this hypothesis and this derivation is that the ancestral Basidiomycetes must have included clamp-bearing forms.

The author desires here to record his indebtedness to the National Research Council for the fellowship during his tenure of which the present investigation was carried on; to Professor William H. Weston, Jr., and Dr. David H. Linder for suggestions and criticism during the course of the work and of the preparation of the manuscript; and especially to his wife, whose drawings illustrate the paper.

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## DESCRIPTION OF FIGURES

All figures were drawn with the aid of a camera lucida at a magnification of 2280 X and fig. 1-33 reduced in reproduction to about 900 X, and fig. 34 to 1000 X. Figures are inverted—i.e., arranged with the supporting hyphae below—for more ready comparison with ascus stages. Figures are all from sections, excepting figure 34 *c-f*, drawn from preparations of crushed material.

Fig. 1-3, successive stages in the development of fertile primordium; 4, 5, formation of beak; 6, conjugate division; 7, 8, late stages of division, and basal migration of stalk nucleus; 9, reorganized nuclei; 10, completed septa; 11, 12, formation of peg for completion of clamp; 13-16, completion of clamp and basal migration of beak nucleus; 17, end of first cycle: dikaryon reconstituted in stalk; 18-21, expansion of apex of clamp, and apical movement of stalk dikaryon; 22, 23, movement of nuclei into expanded summit of clamp; 24, secondary primordium; 25, beak on secondary primordium; 26-29, successive stages in conjugate division in secondary primordium; 30, stalk dikaryon basally placed in stalk common to three basidia; 31-33, formation of tertiary primordium.

Fig. 34 *a-f*: *a*. Section of fruiting-layer of *Sebacina prolifera* (idealized; based on camera-lucida drawings); *b, c, d*, spores; *e, f*, basidia. In fig. *a*, basidia have arisen in the order of numbering: 1, collapsed basidium whose spores have been discharged; 2, portion of disintegrating basidium, borne on the clamp at the base of 1; 3, nearly mature basidium; 4, septate hypobasidium; 5, young probasidium, whose origin from the clamp beside 4 is clearly shown; 6, probasidium developing from the clamp of 5. On the stalk next on the right, 1', disintegrating basidium, shrunk away from its clamp-cell on which the mature basidium 2' is borne; 3', probasidium formed behind 2'; 4', probasidium borne on the clamp beside 3', and in turn bearing 5'; 6', clamp-cell.

# NEW CONIDIAL PHYCOMYCETES DESTRUCTIVE TO TERRICOLOUS AMOEBAE

CHARLES DRECHSLER

(WITH 7 TEXT FIGURES)

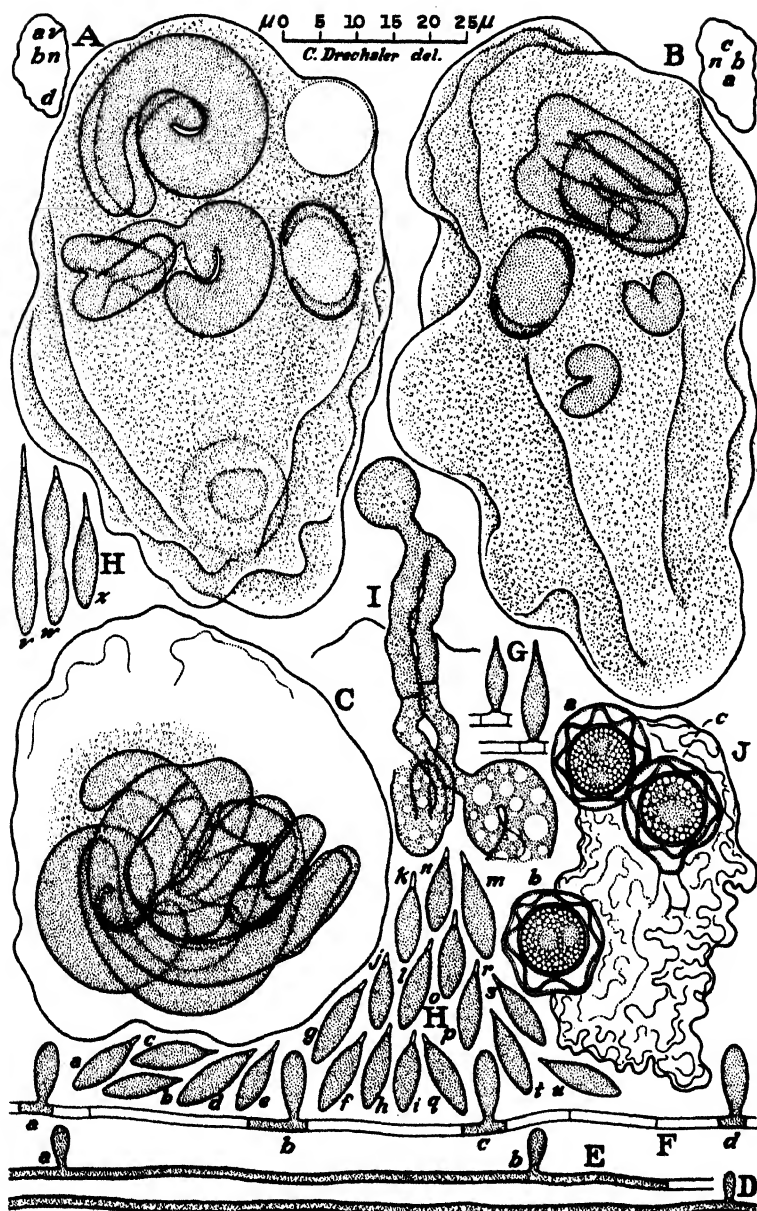
In several previous papers (1, 2, 3, 4) were described a series of conidial Phycomycetes often making their appearance on old agar plate cultures, where they subsist through the destruction of microscopic animals frequently introduced in plantings of decaying vegetable materials. Subsequent observations on laboratory cultures of the same sort have brought to light more than a dozen fungi intimately related to those dealt with before, and like them mainly parasitic or predacious on terricolous *Amoebae*. Most of the additional species are as yet only partially known. Some have been seen only as predacious mycelia devoid apparently of both conidial and sexual apparatus. Others have been observed properly only in their asexual reproductive phases, the delicate underlying mycelia at the time of observation having become largely invisible from the very evacuation of protoplasmic contents entailed in the production of the conidia. Perhaps mainly also because of such obliteration, and the consequent difficulty of tracing a connection to conidial apparatus, a few forms are familiar only through their zygosporangia and zygospores. To increase the difficulties a tract of substratum is very often occupied by a number of predacious fungi, rather than by a single predacious species; so that the hyphae and reproductive bodies of several related forms frequently occur intermingled confusingly in the same area.

Besides five fungi known in all three developmental phases—vegetative, asexual and sexual—two species are described herein, which from their consistent failure hitherto to exhibit zygosporangia and zygospores, will presumably not soon reveal such structures under the conditions of cultivation so far employed. The

seven forms do not extend materially the morphological scope of the Zoopagaceae, all being readily referable to genera previously defined. They afford, however, clarification of a few structural details. Thus the separation of zygosporangium wall into an outer stellate membrane and an inner spherical one, prevailing apparently throughout the genus *Endocochlus*, is shown especially clearly in the sexual apparatus of the species to be described as *E. gigas*. Again, the description of the development of catenulate conidia, as given earlier in the account of *Cochlonema verrucosum* Drechsl., is definitely confirmed in the unusually favorable material now provided by *Zoopage nematospora*. If the confirmation leaves the homologies of the conidial apparatus with the asexual reproductive structures in both the Mucorales and the Entomophthorales as problematical as ever, it makes more precise the morphological similarities to *Actinomyces* to which attention was directed earlier. Somewhat curiously, these similarities might perhaps be considered extended in the provoking even if only partial correspondence between the conspicuously simplified sexual development in *Zoopage cladosperma* and the development of the "Vierhyphensporen," which Lieske (5) observed in many species of *Actinomyces* and regarded as probably representing sexual structures.

#### ENDOCOCHILUS BRACHYSPORUS

On many old agar plate cultures that, after being found infested with various species of nematodes and protozoans, had been planted with pinches of leaf mold received from Ames, Iowa, was found on examination a week or two later, a display of arachnoid conidiiferous filaments having an unmistakable general similarity to the asexual reproductive apparatus of *Endocochilus asteroides* Drechsl. In accordance with expectations each separate system of filaments on being traced backward was found to originate from a partially or wholly evacuated cochleate thallus lying loosely within a membrane, often badly collapsed and wrinkled, that was readily recognizable as the persistent pellicle of an *Amoeba*. Living *Amoebae* bearing internally thalli in various stages of development abounded in some of the cultures (FIG. 1, A, B). These *Amoebae* were approximately of the same dimensions as

FIG. 1. *Endocochlus brachysporus*.

those attacked by *E. asteroides*, the larger specimens measuring about  $60\mu$  in diameter when drawn up into a moderately rounded shape; they showed likewise a fairly substantial pellicle, a relatively transparent, dispersedly granular protoplasm, and a prolate ellipsoidal nucleus frequently about  $15\mu$  long and  $10\mu$  wide. The identity of the host animal with the form previously referred to in a broad sense as *Amoeba terricola* Greeff (and in a narrower sense as *A. terricola* I) was indicated with much certainty through the nucleus consistently revealing a slightly darker, somewhat irregularly concavo-convex body appressed closely to the peripheral membrane at each of its poles (FIG. 1, *A*, *n*; *B*, *n*).

Apart from the evident conspecific identity of the animals attacked, similarity to *Endocochlus asteroides* was apparent in the dimensions and involute arrangement of the vegetative thallus of the fungus itself (FIG. 1, *A*, *a*, *b*; *B*, *a-c*; *C*). The similarity appeared, however, to be somewhat less than complete, as in the Iowa parasite the thallus instead of always branching dichotomously sometimes gave rise to a monopodial branch (FIG. 1, *A*, *b*), which then developed geometrically independent of the parent axis as a subsidiary cochleate structure. That such monopodial branching may take place also in *E. asteroides* and *E. gigas* is, to be sure, not impossible; but, if so, it would seem to occur so rarely as ordinarily to escape notice.

Sexual reproduction in the Iowa parasite follows the same course as in *Endocochlus asteroides* (FIG. 1, *I*); the resulting zygosporangium and zygospore (FIG. 1, *J*, *a-c*) being apparently slightly larger than the homologous structures in the latter species, which, nevertheless, they closely resemble. As in the other known members of the genus, the zygosporangial wall usually collapses perceptibly when the maturing zygospore contracts—this contraction gradually bringing about the stellate contour of the outer zygospore membrane, which ultimately appears to become well separated from the smoothly spherical inner membrane immediately surrounding the protoplast.

The aerial conidiiferous hyphae growing out from the thallus of the Iowa fungus (FIG. 1, *D*, *E*, *G*) give rise to conidia through lateral budding in much the same manner as those of *Endocochlus asteroides*. A fairly conspicuous difference soon appears, how-

ever, in the consistently closer spacing of the conidia on the parent hyphae (FIG. 1, *F*). Correlated with this closer arrangement, the conidia on maturity are noticeably smaller, the lesser bulk being accounted for through a marked inferiority in length (FIG. 1, *H*, *a-u*). The elongate ovoid shape thus brought about is easily distinguished from the more slender fusiform conidial shape characteristic of *E. asteroides*. Even though on examining a large number of conidia, a few specimens (FIG. 1, *H*, *v-x*) can be found comparable to those of the species described earlier, the general run of these bodies maintain their distinctive dimensions and shape with much constancy. The parasite is therefore described under a specific name having reference to its relatively short spore.

**Endocochlus brachysporus** sp. nov.

Hyphae nutritae 4–8.5  $\mu$ , semel vel bis spiraliter convolutae. Conidia fusioidea vel elongato-ovoidea, 7–15  $\mu$  (raro usque 21  $\mu$ ) saepius 8–12  $\mu$  longa, 3–4.2  $\mu$  lata, in apice appendicula vacua 1–3.5  $\mu$  longa praedita, ex hyphis arachnoideis 1.3–1.6  $\mu$  crassis 1–4 mm. longis ad intervalla 25–45  $\mu$  longa enata. Zygosporae hyalinae vel luteolae, echinatae, intra zygosporangium sphaeroideum 12–15  $\mu$  diam. formatae, loculo 6.5–9  $\mu$  diam. Hyphae zygosporiferae 2.5–4  $\mu$  crassae, 25–50  $\mu$  longae.

*Amoebam terricolam* (sensu latiore) enecans habitat in humo silvarum, Ames, Iowa.

Vegetative hyphae 4 to 8.5  $\mu$  in diameter, simple or often when well developed sparingly branched dichotomously or monopodially, and compactly convoluted in 1 to 2 turns. Conidia rather broadly spindle-shaped or elongate ovoid, measuring 7 to 15  $\mu$  (rarely up to 21  $\mu$ ), mostly 8 to 12  $\mu$  (average 10.2  $\mu$ ) in length by 3 to 4.2  $\mu$  (average 3.5  $\mu$ ) in diameter, exclusive of an empty apical appendage 1 to 3.5  $\mu$  (average 1.6  $\mu$ ) long and .5 to 1  $\mu$  wide at the base; produced erect and sessile or nearly sessile at intervals of 25 to 45  $\mu$  on aerial hyphae often 1 to 4 mm. long and 1.3 to 1.6  $\mu$  wide. Zygospore colorless or slightly yellowish; at maturity bul-late, the outer membrane being disposed in 15 to 20 protuberances of which about 6 are visible in the stellate profile; containing a locule 6.5 to 9  $\mu$  in diameter, surrounded by the smooth inner membrane; produced within a spherical zygosporangium mostly 12 to 15  $\mu$  in diameter arising from a short hyphal extension from the junction of paired zygomorphic hyphae that measure usually 25 to 50  $\mu$  in length and 2.5 to 4  $\mu$  in width.

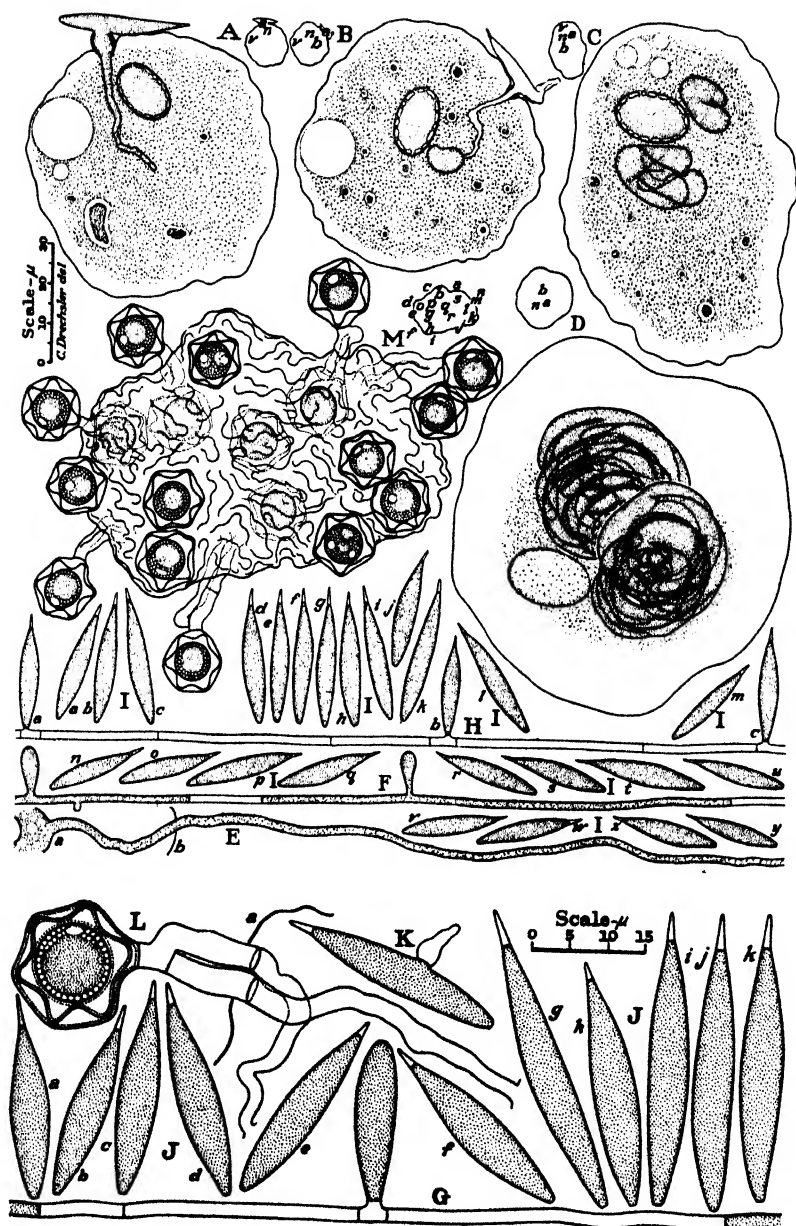
Destructive to *Amoeba terricola* (in the broad sense more particularly of Penard) in leaf mold from Ames, Iowa.



## ENDOCOCHLUS GIGAS

The same sample of leaf mold from which was obtained the fungus just described yielded also a congeneric form much more impressive in its generous dimensions. This larger species was found to confine its attack exclusively to an *Amoeba* measuring mostly 60 to 110  $\mu$  in diameter. In its firm substantial pellicle and its transparent, dispersedly granular protoplasm the animal showed similarities to the one habitually parasitized by *Endocochlus asteroides* and *E. brachysporus*, as well as to the *Amoeba* serving as host to *Bdellospora helicoides* Drechsl. In its nucleus, however, it was markedly different from both. Viewed in optical section, this prolate ellipsoidal structure, which measured often about 20  $\mu$  in length by 13  $\mu$  in diameter, revealed the darker material as rod-like parts arranged in an interrupted ring close to the periphery (FIG. 2, *A, n; B, n; C, n*); although on focusing on the upper and lower surfaces the darker parts appeared more nearly as if connected in a continuous reticulum. Because of the close correspondence in shape and composition with the nucleus set forth as characteristic of *A. terricola* (6), it would seem that Greeff's binomial is applicable here in a narrower sense.

Infection is accomplished in the same manner as has been described for *Endocochlus asteroides*. Germination of an adhering conidium here likewise first results in a somewhat swollen protuberance that clearly betrays its character as an appressorium by its easily visible coating of yellowish adhesive material (FIG. 2, *A, a*). In spite of this adhesive material, the animal sometimes must manage to disengage itself successfully, as a living detached conidium is occasionally to be found bearing an empty appressorium with an empty incipient germ tube (FIG. 2, *K*). When no mishap intervenes the germ tube penetrates well towards the center of the animal, often taking a somewhat irregular course (FIG. 2, *A*). With the disarticulation of the swollen body resulting from the migration of the conidial contents to the tip of the germ tube (FIG. 2, *B, a, b*), appropriation of the substance of the host begins. The animal endures the continuing depletion of its protoplasm with remarkable fortitude (FIG. 2, *C*), but finally succumbs when the small residue of cytoplasm together with the visibly degenerating

FIG. 2. *Endocochlus gigas*.

nucleus (FIG. 2, *D*, *n*) is no longer able to actuate the relatively little diminished pellicle.

Owing no doubt to the large supply of food material in the massive sarcode of the host animal, the thallus of the present fungus often attains a size never observed to be equalled in *Endocochlus asteroides* and *E. brachysporus*. The two impressive thalli shown in figure 2, *D*, *a*, *b*, each consisting of a stout filament bifurcating three times in succession and coiled in three turns, are yet individually of smaller bulk than a thallus developing alone in a host animal of comparable or, perhaps, even larger dimensions. Just as in the two congeneric forms, the contents of the thallus must be of extraordinary concentration; for the output of reproductive apparatus, whether sexual or asexual, is always far in excess of what might reasonably be expected from the volume of the vegetative structure from which it arises.

The hyphae associated with asexual reproduction, including the usually submerged and sterile proximal portions (FIG. 2, *E*) as well as the aerial or somewhat prostrate conidiiferous prolongations that radiate for several millimeters above the dead host animal, are noticeably stouter than the corresponding elements of *Endocochlus asteroides* and *E. brachysporus*. The conidia, half again as wide and nearly three times as long as those of *E. brachysporus*, arise at intervals approximately three times as long as the intervals in that species (FIG. 2, *F-H*). As in the two congeneric species the apex of the conidium is evacuated toward maturity and persists as an empty conical appendage (FIG. 2, *H*, *a-c*; *I*, *a-y*; *J*, *a-k*). Considered by itself the spindle-shaped living cell is rather similar in size and shape to the living cell in the conidium of *Acaulopage ceratospora* Drechsl.

Sexual reproduction would seem, in general, more abundant than in *Endocochlus brachysporus*. As many as 24 zygospores have been found clustered about the collapsed pellicle of what before must have been an unusually large animal; therefore the output represented in figure 2, *M*, *a-s*, consisting of 19 such spores cannot be considered extreme. The zygosporangia and zygospores are noticeably larger than those of the two known congeneric species; so that the separation of the stellate outer zygospore membrane from both the enveloping zygosporangial wall and the spher-

ical membrane surrounding the locule is more clearly evident (FIG. 2, L). Within the locule the arrangement of contents widely prevalent in oospores is recognizable: an elliptical refringent body, or sometimes two such bodies, being imbedded in the parietal layer of uniformly coarse granules that surrounds the relatively large, vacuole-like reserve globule.

A term having reference to the large dimensions of the fungus is deemed appropriate as a specific name.

### **Endocochlus gigas** sp. nov.

Hyphae nutritae 3.5–9.5  $\mu$  diam., bis vel ter spiraliter convolutae. Conidia fusoidca, 21–36  $\times$  4.4–6.2  $\mu$ , in apice appendicula 2.2–5  $\mu$  longa praedita, ex hyphis arachnoideis 1–5 mm. longis 1.8–2.3  $\mu$  crassis ad intervalla 80–130  $\mu$  longa enata. Zygosporae hyalinae vel luteolae, echinatae, intra zygosporangium sphaeroideum 13–17  $\mu$  diam. formatae, loculo 8–10  $\mu$  diam. Hyphae zygosporiferae 1.5–4  $\mu$  crassae, 25–60  $\mu$  longae.

*Amoeba terricola* (sensu strictiore) enecans habitat in humo silvarum, Ames, Iowa.

Vegetative hyphae 3.5 to 9.5  $\mu$  in diameter, when well developed often bifurcating 3 times in succession and convoluted compactly in 2 to 3 or even 3½ turns. Conidia spindle-shaped, measuring 21 to 36  $\mu$  (average 28  $\mu$ ) in length by 4.4 to 6.2  $\mu$  (average 5.1  $\mu$ ) in diameter, exclusive individually of an empty pointed apical appendage 2.2 to 5  $\mu$  (average 3.6  $\mu$ ) long and .8 to 1.2  $\mu$  wide at its base; produced erect and sessile or nearly sessile at intervals of 80 to 130  $\mu$  on aerial hyphae 1 to 5 mm. long and 1.8 to 2.3  $\mu$  wide, that ramify more or less to extend over the substratum in a somewhat arachnoid pattern. Zygospore colorless or slightly yellowish, its outer membrane disposed in 15 to 20 bullate protuberances of which usually 6 or 7 are visible in the stellate profile, its smooth inner membrane surrounding a subspherical locule 8 to 10.5  $\mu$  in diameter; produced within an originally subspherical zygosporangium measuring 13 to 17  $\mu$  in diameter and borne on a short hyphal extension from the junction of zygomorphic hyphae 1.5 to 4  $\mu$  wide and 25 to 60  $\mu$  long,—the zygosporangial wall at maturity collapsing loosely about the bullate zygospore membrane.

Destructive to *Amoeba terricola* (in a stricter sense) in leaf mold from Ames, Iowa.

### ACAULOPAGE CERCOSPORA

A fungus readily referable to the genus *Acaulopage* made its appearance several times on old agar plate cultures to which had

been added pinches of muck originating from near South Bend, Indiana. Like the other members of the genus it subsists on *Amoebae*, the animals captured by it, mostly 10 to 20  $\mu$  in diameter, belonging evidently to a single species. As no nucleus could be distinguished in the peculiarly turbid and mostly homogeneous protoplasm bounded by the very delicate, scarcely visible pellicle, the identity of the prey could not be determined. The materials composing the smaller animals are usually assimilated by means of a single haustorium, consisting of a stalk together with several wider elements branching from it (FIG. 3, *A, a; B; C; E*). Larger animals, however, often occasion the production of two (FIG. 3, *D*) and sometimes three or four haustoria, especially when capture takes place at the junction of two branches (FIG. 3, *A, b*), or where two filaments happen to lie near one another.

Closely resembling the haustorial stalks in dimensions, the sterigmata on which the conidia are borne singly arise erect from the prostrate superficial hyphae (FIG. 3, *C-I*) at rather close intervals. Though the sterigmata and the fertile hyphae together have an appearance suggestive of the homologous structure in *Acaulopage macrospora* Drechsl., the similitude is not extended to the conidia, which consist here individually of a rather small elongated ellipsoidal living cell bearing distally a relatively long, narrow, empty appendage (FIG. 3, *E-I*). Conspicuous differences from the conidium of *A. ceratospora* are evident in the much smaller dimensions throughout and in the absence of a basal appendage. When viewed under a dry objective, the conidia, bristling in close linear arrangement in an open arachnoid pattern corresponding to the disposition of the prostate hyphae, present a most distinctive appearance.

Sexual reproduction has never been observed. A term having reference to the tail-like conidial appendage would seem appropriate as specific name for the fungus.

### ***Acaulopage cercospora* sp. nov.**

Paulo sparsa; hyphis incoloratis, 1-1.7  $\mu$  crassis; haustoriis ex stipe et 4-6 lobulis vel ramulis divaricatis 1.2-2  $\mu$  crassis compositis. Conidia solitaria, ex sterigmatibus erectis 2-5.5  $\mu$  altis orta, hyalina, appendiculata: Cellula viventi protoplasmatis repleta, fusioidea vel elongato-ellipsoidea, 7-15  $\mu$

longa, 2.2–3.6  $\mu$  crassa, appendicem apice ferente; appendice vacua, angustata, 6–20  $\mu$  longa, .4–.8  $\mu$  crassa, in aere saepe marcida. Zygosporae ignotae.

Habitat in humo palustri, *Amoebas* 10–20  $\mu$  latas capiens et consumens, prope South Bend, Indiana.

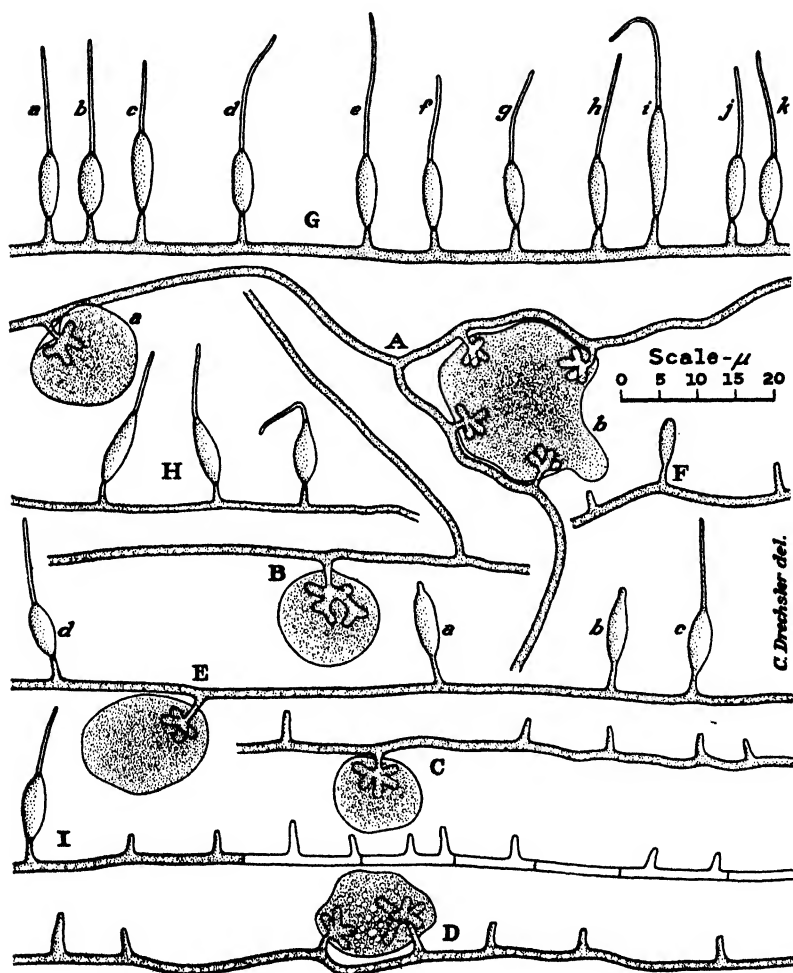


FIG. 3. *Acaulopage cercospora*.

Somewhat sparse; hyphae colorless, 1 to 1.7  $\mu$  wide, producing stalked haustoria with 4 to 6 spreading lobate or digitate elements mostly 1.2 to 2  $\mu$  wide. Conidia hyaline, solitary; borne on erect, somewhat tapering sterigmata, 2 to 5.5  $\mu$  high, that arise at intervals of 5 to 30  $\mu$  from superficial prostrate filaments; consisting

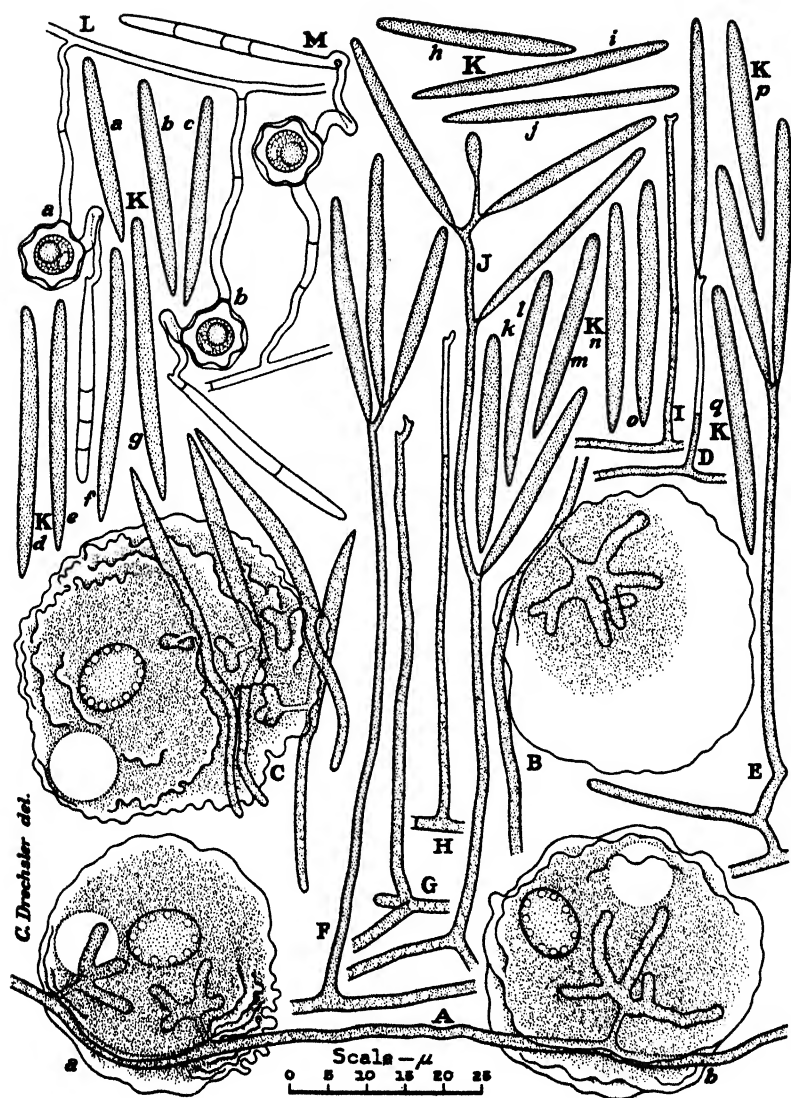
individually of a living fusoid or elongated ellipsoid cell 7 to 15  $\mu$  (average 9.1  $\mu$ ) long and 2.2 to 3.6  $\mu$  (average 2.8  $\mu$ ) wide, together with an empty narrow distal appendage, often withered on exposure to air and measuring 6 to 20  $\mu$  (average 12.2  $\mu$ ) in length by .4 to .8  $\mu$  in width.

Occurring in muck soil near South Bend, Indiana; capturing and destroying *Amoebae* mostly 10 to 20  $\mu$  in diameter.

#### STYLOPAGE RHABDOSPORA

A species of *Stylopaga* different from any of the four forms hitherto assigned to that genus appeared in a few old agar plate cultures on which had been planted pinches of leaf mold collected in a wooded tract in Clarendon, Virginia. In all instances it subsisted apparently altogether by the capture of *Amoebae* undoubtedly referable to a single species. The animal taken measured mostly from 30 to 40  $\mu$  in diameter when drawn into an approximately round shape. Except for a sappy homogeneous layer immediately under the delicate pellicle, the protoplasm consisted of rather densely and coarsely granular material, which was nevertheless sufficiently transparent to reveal very clearly a single prolate ellipsoidal nucleus mostly 9 to 10  $\mu$  in length and 7 to 8  $\mu$  in diameter (FIG. 4, *A*, *a*, *b*; *C*). In optical section this nucleus revealed close under its own membrane about a dozen subspherical masses of slightly darker material. The nuclear structure represented here thus corresponds to that which Penard (6) once figured as being characteristic of an *Amoeba* he considered probably identical with *Amoeba similis* Greeff. Adoption of the binomial mentioned has at least the advantage of setting the animal in question apart from any of the four forms to which I have referred as *A. terricola*.

The mycelium of the fungus is rather sparse, being composed of filaments that often traverse relatively long distances in a nearly straight line without giving off any branches. When contact with a susceptible *Amoeba* has been effected, a delicate process is thrust through the pellicle some distance into the protoplasm, there widening abruptly and branching dichotomously with a variable degree of regularity, and thus giving rise to a haustorium comparable, for example, to that of *Acaulopaga macrospora* (FIG. 4, *A*, *a*, *b*). De-

FIG. 4. *Stylopaga rhabdospora*.



pletion of the protoplasmic materials of the rhizopod continues until little remains but the pellicle (FIG. 4, *B*).

Haustoria are often produced also by adhering conidia when an animal has had the ill fortune to encounter one or often several of these bodies in moving over the surface of a substratum strewn with them (FIG. 4, *C*). In performance, therefore, and, indeed, in general appearance as well, the conidia (FIG. *K*, *a-g*) recall those of *Acaulopage macrospora*; differing from them, however, in their smaller dimensions and in being borne on hyphae of sufficient height to deserve to be regarded as conidiophores (FIG. 4, *E-J*). After giving rise to one conidium, these conidiophores, like the homologous structures of *Stylopage leptе* and *S. hadra*, often produce others following repeated prolongation below successive spores in the manner of development made familiar in *Phytophthora infestans* (Mont.) de Bary.

The production of a haustorium directly from a conidium does not preclude simultaneous production of a vegetative germ hypha (FIG. 4, *C*). In instances where a conidium germinates by giving rise directly to a zygophore (FIG. 4, *L, M*), the protoplasmic contents are usually contributed in their entirety to the resulting sexual apparatus. Just as in similar sexual development already noted in some related forms, the progressive evacuation of the conidium is generally accompanied by the laying down of a number of successive cross-walls.

Sexual apparatus is formed in moderate quantity wherever the fungus attains any considerable growth, pairs of zygophoric branches arising either from separate hyphae having no close mycelial connection with each other, or from a hypha and a conidium, or from two conidia. Fusion of the sexual branches at their tips, development of a spherical zygosporangium at the junction, delimitation of the fusion cell by septa, and transformation of its contents into a yellowish zygospore with a relatively thick bullate wall, show unmistakable parallelism with sexual development in related species such as *Zoopage phanera* Drechsl. and *S. leptе*. Indeed, as the latter congeneric form was present in quantity in all cultures wherein the fungus under discussion was found, the structural parallelism between the intermingled sexual reproductive

bodies was evident to a troublesome degree. The dimensional differences, to be sure, were in nearly all cases, sufficient to distinguish the product of the one species from that of the other; though in choosing specimens for illustration it was thought advisable to obviate the possibility of error by selecting only unambiguous apparatus originating at least partly from conidia.

A term having reference to the rodlike shape of the conidium is deemed tolerably appropriate as specific name for the fungus.

### **Stylopage rhabdospora** sp. nov.

Sparsa; hyphis sterilibus incoloratis, 1–1.8  $\mu$  crassis, haustoria pedicellata evolventibus; pedicello saepius .6–.8  $\mu$  crasso, 2–4  $\mu$  longo, ramulis dichotomis, divaricatis, 1.2–2  $\mu$  crassis, usque 15  $\mu$  longis; hyphis fertilibus incoloratis, 20–100  $\mu$  altis, basi .8–1.5  $\mu$  crassis, sursum saepe paulatim attenuatis, apice .6–1.2  $\mu$  crassis, usque 4 conidia post incrementa brevia repetita ferentibus. Conidia elongato-cylindracea, sursum leniter attenuata et abrupte rotundata, deorsum plerumque attenuata, itaque basi acutiuscula, 22–38  $\mu$  longa, 2.2–2.8  $\mu$  lata. Zygosporangia primo levia, sphaeroidea, 7.5–9.5  $\mu$  diam., in maturitate membrana circa zygosporam collabente; zygospora flavida, sphaeroidea, 6.5–8.5  $\mu$  diam., membrana .7–1.7 crassa, 10–20 verrucis ornata.

Habitat in materiis plantarum putrescentibus, praecipuo in humo silvarum, *Amoebam similem* capiens et consumens, Clarendon, Virginia.

Sparse; vegetative hyphae colorless, 1 to 1.8  $\mu$  wide, producing haustoria composed individually of a stalk mostly .6 to .8  $\mu$  wide and 2 to 4  $\mu$  long, together with spreading, irregularly dichotomous branching elements 1.2 to 2  $\mu$  wide and up to 15  $\mu$  long; fertile hyphae colorless, 20 to 100  $\mu$  high, .8 to 1.5  $\mu$  wide at the base, usually tapering gradually to an apical width of .6 to 1.2  $\mu$ , bearing mostly from 1 to 4 conidia, of which those following the first are formed after repeated, usually rather slight elongation. Conidium elongated cylindrical, generally tapering rather slightly toward the abruptly rounded apex, and more markedly toward the somewhat acute base, 22 to 38  $\mu$ , mostly 25 to 35  $\mu$  (average 30  $\mu$ ) long, and 2.2 to 2.8  $\mu$  (average 2.5  $\mu$ ) wide. Zygosporangium at first smooth, spherical, 7.5 to 9.5  $\mu$  in diameter, its wall at maturity collapsing loosely about the zygospore; zygospore yellowish, subspherical, 6.5 to 8.5  $\mu$  in diameter, with a wall, .7 to 1.7  $\mu$  thick, ornamented with 10 to 20 wartlike protuberances, of which 6 to 8 are visible in the sigillate profile.

Occurring in decaying plant materials, especially in leaf mold, capturing and consuming *Amoeba similis*, Clarendon, Virginia.

## ZOOPAGE ATRACTOSPORA

The leaf mold from Ames, Iowa, that gave rise to *Endocochlus brachysporus* and *E. gigas*, yielded in nearly all of the old agar plate cultures to which it was added, flourishing growths of a fungus immediately recognizable as a species of *Zoopage*. The plate cultures used were infested very abundantly with a species of *Amoeba* measuring mostly 12 to 25  $\mu$  in diameter when drawn into a fairly rounded shape. In the normal animal a pellicle could hardly be recognized, though an individual depleted largely of its protoplasmic material generally revealed a very delicate envelope (FIG. 5, B). Very probably because of the characteristic turbidity of the protoplasmic body, no nucleus, nor, indeed, any normal structure except a relatively small contractile vacuole could be definitely made out (FIG. 5, A; C; D; G, a); the animal thus showing a general similarity to the one captured by *Acaulopage cercospora*. On this protozoan the fungus subsisted evidently to the exclusion of other sources of nourishment, capture being effected by adhesion to submerged as well as superficial hyphae, and assimilation being accomplished by means of haustoria bearing individually a half dozen divergent elements on a slender stalk (FIG. 5, A-D; G, a).

Nourished from an extraordinarily abundant supply of *Amoebae* the fungus gave rise to a tangled profusion of conidial chains that often extended over large areas of the plate cultures and became visible to the naked eye as a delicate efflorescence. Perhaps most of the chains consisted of approximately 10 spores, though many were found containing more than twice that number. As in *Zoopage phanera* the young chains are represented by continuous, somewhat moniliform filaments constricted at fairly regular intervals. The presence frequently of a minute swollen bud at the tip of an elongating moniliform filament (FIG. 5, E, F) supplies good evidence that increase of swollen components ensues through successive proliferation from the constricted apex of the component last completed. After the filament has attained its definitive length, the insertion of two crosswalls a short distance from one another in the narrowest part of each isthmus, preceded presumably by evacuation of the very minute constricted section, brings about the conversion of the swollen components into separate conidia (FIG. 5, C, b; E, b). Though most of the conidia

FIG. 5. *Zoopage attractospora*.

(FIG. 5, *S a-y*) are rather acute at both ends the terminal conidium of each chain (FIG. 5, *C, b*; *E, b*) is recognizable even after disarticulation by its broadly rounded apical extremity. Branching of a chain especially near its base occurs with some frequency, resulting in occasional bifurcate conidia (FIG. 5, *C, c*; *S, n*). Somewhat analogous branching of the relatively short, erect sterigmata, or of the parent hyphal branches in close proximity to them, is equally frequent (FIG. 5, *E, a-c*), but is reflected merely in the spore chains arising in small groups, rather than in the shape of the spore itself.

In spite of the general resemblance of the conidial apparatus to that of *Zoopage phanera*, specific differences are easily recognized. The conidia of the present species are conspicuously shorter, and as might be expected from the smaller diameter of the mycelial hyphae, also narrower than those of the form described earlier. In *Zoopage phanera* the variation in width of conidium is relatively small; and in any particular spore, width seems little influenced by length, so that the longer specimens are also very generally proportionately bulkier. Whereas in the fungus under consideration the longer conidia (FIG. 5, *S, b, m, n, r, s, v*) are often noticeably narrower than the shorter ones (FIG. 5, *S, d, i, j, l, o, u, w, y*), variation in one dimension being, therefore, in some measure compensated by opposite variation in the other. Moreover, the verrucose sculpturing of the conidial membrane, though visible in dry preparations, is much less prominent than in *Z. phanera*, being mostly so minute that at the magnification of the accompanying figure, it could hardly be shown without considerable exaggeration.

On the other hand, the sexual reproductive structures of the fungus closely resemble those of *Zoopage phanera*: similarities being evident, for example, in the origin of zygospores from conidia (FIG. 5, *K, a*; *L, a*) as well as from mycelial filaments (FIG. 5, *G, b*; *H; I; J, a, b*; *K, b*; *L, b*); in the size of the zygosporangium and the noticeable collapse of its wall at maturity (FIG. 5, *M-R*); and in the size, coloration and bullate sculpturing of the zygospore itself (FIG. 5, *M-R*).

A term having reference to the spindle-like shape characteristic more particularly of its shorter conidia, may perhaps serve acceptably as specific name for the fungus.

***Zoopage atractospora* sp. nov.**

Mycelium ramosum; hyphis hyalinis, saepe irregulariter flexuosis, 1-2  $\mu$  crassis; haustoriis pedicellatis, pedicello 1.5-4  $\mu$  longo, .5-1  $\mu$  crasso, 4-8 ramulos digitatos circa 1.2-1.5  $\mu$  crassos ferente. Conidia minute et imperspicue verrucosa, fusioidea vel elongato-fusioidea, interdum bifurcata, 10-45  $\mu$  longa, 1.4-2.7  $\mu$  crassa in calenulis ex apice attenuato sterigmatum brevium et interdum ramosorum oriunda, in quaque catenula quina usque vicena quina. Zygosporangia 8-11.5  $\mu$  diam., primum levia, mox paulo collabentia. Zygosporae flavida, 6.5-10  $\mu$  diam., membrana .6-1.8  $\mu$  crassa, loculo 5-6.7  $\mu$  diam.; 15-25 verrucis ornata.

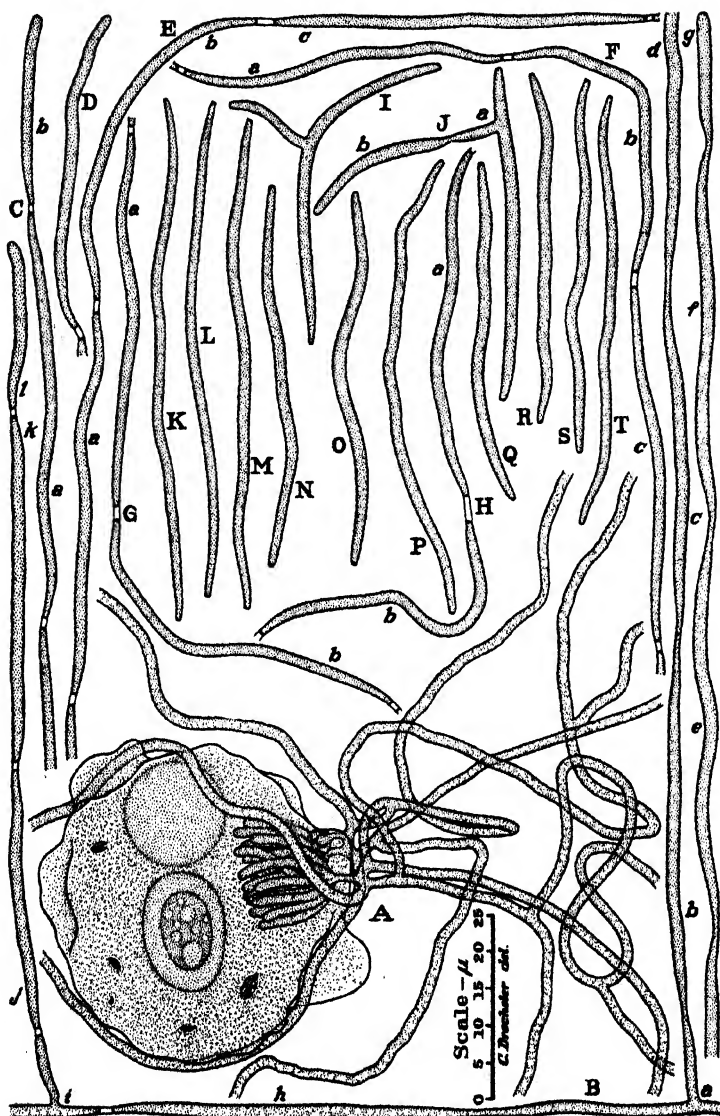
*Amoebas* 12-25  $\mu$  latas capiens et consumens habitat in humo silvarum, Ames, Iowa.

Mycelium branched; hyphae hyaline, often following irregular haphazard courses, 1 to 2  $\mu$  wide; haustoria pedicellate, the pedicels 1.5 to 4  $\mu$  long, .5 to 1  $\mu$  wide, and bearing 4 to 8 digitate branches 1.2 to 1.5  $\mu$  wide. Conidia minutely and very inconspicuously warted, fusiform or elongated fusiform, sometimes distally forked; measuring 10 to 45  $\mu$ , mostly 17 to 37  $\mu$  (average 25  $\mu$ ) in length, and 1.4 to 2.7  $\mu$  (average 2.1  $\mu$ ) in width; produced in chains of 5 to 25 on tapering, short, yet sometimes branched sterigmata. Zygosporangium 8 to 11.5  $\mu$  in diameter, at first smooth, at maturity collapsing loosely about the sculptured zygospore. Zygospore yellowish, 6.5 to 10  $\mu$  in diameter, with a locule 5 to 6.7  $\mu$  in diameter and a wall .6 to 1.8  $\mu$  thick; the wall provided with 15 to 25 warty protuberances of which 6 to 8 are usually visible in the sigillate contour.

Occurring in leaf mold, capturing and consuming *Amoebae* mostly 12 to 25  $\mu$  in diameter, Ames, Iowa.

## ZOOPAGE NEMATOSPORA

A species of *Zoopage* markedly different from *Z. phanera* and *Z. atractospora* developed luxuriantly in a series of old agar plate cultures to which had been added pinches of decaying vegetable matter collected by S. P. Doolittle and F. L. Wellman in a ditch at the Subtropical Experiment Station near Homestead, Florida, early in March, 1935. In these cultures it lived from all appearances exclusively on the numerous *Amoebae* that it held fast on its mycelium and depleted of substance by means of stalked haustoria whose longish digitate absorptive elements were displayed in a characteristically graceful broom-like arrangement (FIG. 6, A). The *Amoebae* captured measured mostly from 40 to 50  $\mu$  in diam-

FIG. 6. *Zoopage-atractospora*.

eter, and were surrounded individually by a moderately substantial pellicle. A single roughly ellipsoid nucleus, composed of an outer clearer layer and a darker ellipsoid body interspersed with a number of clearer lacunae, was visible in the flocculently granular protoplasm of the rhizopod. The dimensions of the animal, together with the shape and composition of its nucleus, would seem indicative of identity with the form discussed by Penard (6) under the binomial *Amoeba striata* Pen.

Aside from the distinctive design of its haustorium, the fungus shows little in its vegetative stage to set it apart from the several other known members of the genus. At times the individual hyphae pursue fairly straightforward courses; but again, for no evident reason, they follow capricious bends. The tendency toward haphazard arrangement is expressed also in the aerial filaments devoted to asexual reproduction. These filaments reveal less differentiation from the vegetative hyphae than in other species, the narrowed parts being not only spaced at longer intervals but also constricted less, ordinarily, indeed, measuring about one-half as much in width as the intervening parts (FIG. 6, *B*, *a-h*). When the isthmi are evacuated of protoplasm for lengths often equivalent to twice their widths, and the protoplasts thus separated deposit a delimiting septum at each of their respective ends, the filament becomes converted into a chain of spores (FIG. 6, *B*, *i-l*; *C-H*). Ramification of the sporiferous hyphae (FIG. 6, *B*, *a, i*), which would seem fully as frequent as in *Zoopage atractospora*, here likewise results in occasional branched spores (FIG. 6, *I, J*). Of evident flexibility when subjected to mechanical disturbances, as, for example, in being mounted for microscopic examination, and of a relatively small diameter little given to variation except for the rather slight tapering toward the two ends, the longish conidia present a threadlike appearance that has suggested the specific name proposed for the fungus.

### ***Zoopage nematospora* sp. nov.**

Mycelium ramosum; hyphis hyalinis, saepe irregulariter flexuosis, 1.1–1.9  $\mu$  crassis; haustoriis pedicellatis, pedicello 1.5–4  $\mu$  longo, .7–1  $\mu$  crasso, 5–12 ramulos digitatos, 5–13  $\mu$  longos, 1.2–1.5  $\mu$  crassos, scopis paulo similiter digestos ferente. Conidia interdum bifurcata sed saepius filiformia, utrimque paulo attenuata, flexilia, saepius 35–65  $\mu$  longa, 1.5–2.1  $\mu$  crassa, in catenulas



saepe longas simplices vel furcatas digesta, in quaque catenula usque vicena. Zygosporae ignotae.

Habitat in materiis plantarum putrescentibus, *Amoebam striatam* capiens et consumens, prope Homestead, Florida.

Mycelium branched; hyphae hyaline, often following irregular haphazard courses, 1.1 to 1.9  $\mu$  wide; haustoria pedicellate, the pedicel 1.5 to 4  $\mu$  long, .7 to 1  $\mu$  wide, and bearing in somewhat scopulate arrangement usually 5 to 12 digitate branches mostly 5 to 13  $\mu$  long and 1.2 to 1.5  $\mu$  wide. Conidia occasionally branched but more regularly filiform, rather slightly tapering at the ends, flexible, measuring 23 to 71  $\mu$ , mostly 35 to 65  $\mu$  (average 50  $\mu$ ) in length, and 1.5 to 2.1  $\mu$  (average 1.7  $\mu$ ) in width; produced in numbers up to 20 in usually long, simple or branched chains, wherein they are separated from one another by evacuated narrow portions of filament mostly 1 to 2  $\mu$  long and .7 to 1  $\mu$  wide. Zygospires unknown.

Occurring in decaying plant materials, capturing and consuming *Amoeba striata*, near Homestead, Florida.

#### ZOOPAGE CLADOSPERMA

A species of *Zoopage* somewhat smaller than any of the three congeneric forms so far described, appeared in an old agar plate culture to which had been added a few pinches of leaf mold gathered in Clarendon, Virginia. The meager development of the fungus was probably due in part to the relative scarcity of the animal on which it preyed,—an *Amoeba* measuring usually about 15 or 20  $\mu$  in diameter, with a very delicate, inconspicuous pellicle and rather turbid, slightly granular protoplasm. Capture was effected by adhesion to submerged as well as to superficial hyphae; after which the substance of the protozoan was appropriated by means of a haustorium consisting of a slender stalk and thickened dichotomous absorptive branches (FIG. 7, *A*, *a*).

The conidia of the fungus, though much smaller, resembled those of *Zoopage phanera* in their elongate fusiform shape and readily noticeable verrucose sculpturing (FIG. 7, *B*; *C*, *a-o*). Branching of the conidial chains, or of the erect tapering sterigmata on which they were borne, was not observed. It is possible that the absence of such branching, and also the moderate development of the simple chains (FIG. 7, *B*), may have been an expression of restricted luxuriance rather than of a definite morphological tendency.

In its sexual apparatus the species reveals a departure from the relationship prevalent not only in the genus, but throughout the family to which it belongs. A fusion of separate branches ap-

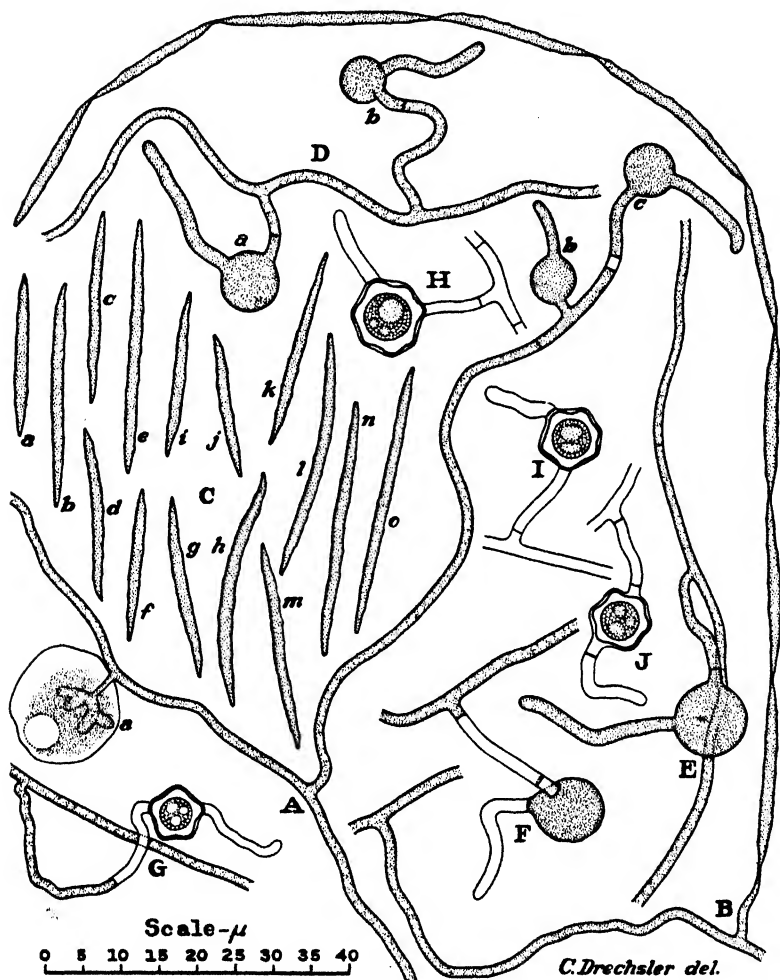


FIG. 7. *Zoopage cladosperma*.

parently never occurs. The zygosporangium makes its appearance first as a globose swelling some distance below the tip of a slightly thickened branch of limited length arising laterally from an ordinary mycelial filament. After the swelling has attained a certain

size, a septum is inserted a short distance below it, leaving the globose part still continuous distally with the apical portion of filament above it, and proximally with the portion of filament extending to the septum (FIG. 7, *A, c; D, a, b; E*). The contents of both portions of filament now pass into the globose part, which then becomes more closely delimited as a fully grown zygosporangium by the insertion of an approximately tangential septum at both of its poles (FIG. 7, *F*). Internal development ensues much as in *Zoopage phanera* and *Z. atractospora*, and yields here likewise a zygospore with bullate sculpturing and sigillate profile (FIG. 7, *G-J*).

Variations occur in the mycelial relationships of the sexual apparatus, as in instances, for example, where the proximal filamentous element consists of an intercalary segment of the axial hypha (FIG. 7, *A, b*). In any case the make-up of the very simple apparatus is such that were it found in the Mucoraceae the resultant reproductive body would almost certainly be regarded as an azygospore. In the series of predacious Phycomycetes under consideration, however, owing to the absence in declinous forms, of septa delimiting anything definitely recognizable as gametangia previous to fusion of separate hyphal tips, any distinction between an azygospore on the one hand, and, on the other, a zygospore formed presumptively through integration of portions of hypha continuous with one another from the beginning, would be much more difficult. The general analogy in development, and more particularly the passage of the protoplasmic contents of the two portions of filament into the young zygosporangium, seems to betoken a close parallelism in essential sexual processes, even though an outwardly manifest fusion entailing a breakdown of hyphal membranes is obviated.

A term having reference to the usual production of the zygospore in a special branch is deemed appropriate as specific name for the fungus.

### ***Zoopage cladosperma* sp. nov.**

Mycelium ramosum, sparsum; hyphis hyalinis, 1-1.6  $\mu$  crassis; haustoriis pedicellatis, pedicello 1.5-3  $\mu$  longo, circa .7  $\mu$  crasso, aliquot ramulos dichotomos divaricatos digitatos circa 1.5  $\mu$  crassos ferente. Conidia minute sed distincte verrucosa, elongato-fusoidea, 18-36  $\mu$  longa, 1.3-1.8  $\mu$  crasso ex

apice hypharum brevium oriunda, in quaque catenula quina usque quina dena. Zygosporangia non ex copulatione hypharum separatarum sed in ramo saepius breviusculo usque  $2\mu$  crasso sub apice ejusdem sine copulatione manifeste orta,  $7-10\mu$  diam., primum levia, in maturitate paulo collabentia. Zygosporae flavidae,  $6-8.5\mu$  diam., loculo  $4.2-6.5$  diam., membrana  $.6-1.5\mu$  crassa,  $12-20$  verrucis ornata.

*Amoebas*  $15-20\mu$  latas capiens et consumens, habitat in humo silvarum, Clarendon, Virginia.

Mycelium branched, sparse; hyphae hyaline, 1 to  $1.6\mu$  wide; haustoria pedicellate, the pedicel mostly  $1.5$  to  $3\mu$  long and  $.7\mu$  wide bearing several bifurcating divergent digitate branches up to  $1.5\mu$  in thickness. Conidia minutely but distinctly verrucose, elongated fusiform, 18 to  $36\mu$  (average  $26\mu$ ) long,  $1.3$  to  $1.8\mu$  (average  $1.5\mu$ ) wide, and produced in chains mostly of 5 to 15 on distally attenuated, rather short, erect branches. Zygosporangium not arising from the union of separate hyphae but developing without cellular fusion some distance below the apex of a usually rather short branch up to  $2\mu$  wide; when fully grown 7 to  $10\mu$  in diameter, at first smooth, later collapsing somewhat about the sculptured zygospore. Zygospore yellowish, 6 to  $8.5\mu$  in diameter, with a locule  $4.2$  to  $6.5\mu$  in diameter and a wall  $.6$  to  $1.5\mu$  thick; the wall provided at maturity with 12 to 20 bullate protuberances, of which 5 to 7 are usually visible in the sigillate profile.

Occurring in leaf mold, capturing and consuming a species of *Amoeba* mostly 15 to  $20\mu$  in diameter; Clarendon, Virginia.

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## EXPLANATION OF FIGURES

Fig. 1. *Endocochlus brachysporus*; drawn with the aid of the camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, *Amoeba terricola* I infected with two thalli, *a* and *b*; *d*, digestive vacuole; *n*, nucleus; *v*, contractile vacuole. *B*, *A. terricola* I infected with two small thalli, *a* and *b*, as well as with a larger thallus *c*; *n*, nucleus. *C*, *A. terricola* I depleted of protoplasm by the three compacted thalli within the pellicle. *D*, *E*, *F*, Portions of conidiiferous hyphae, showing successively later stages in the formation of conidia. *G*, Conidia previous to evacuation of their respective tips. *H*, Mature conidia: *a-u* representing a random assortment; *v*, *w*, *x*, specimens unusual in length, shape and length of appendage respectively. *I*, Zygothores and developing zygosporangium. *J*, Collapsed pellicle of host animal and three mature zygosporangia, *a-c*.

Fig. 2. *Endocochlus gigas*; drawn with the aid of the camera lucida at a uniform magnification. *A*, *Amoeba terricola* being penetrated by a germ tube from the adhering conidium *a*; *n*, nucleus; *v*, contractile vacuole;  $\times 500$ . *B*, An infected specimen of *A. terricola*, the adhering conidium *a* having become emptied in giving rise to the young thallus *b*; *n*, nucleus; *v*, contractile vacuole;  $\times 500$ . *C*, A specimen of *A. terricola* containing two thalli of the parasite, *a* and *b*; *n*, nucleus; *v*, group of vacuoles about to merge into a single contractile vacuole;  $\times 500$ . *D*, Dead or dying specimen of *A. terricola* with two well developed thalli, *a* and *b*; *n*, degenerating nucleus;  $\times 500$ . *E*, Submerged portion of asexual reproductive filament;  $\times 500$ . *F*, Aerial hypha with two conidia in early stages of development;  $\times 500$ . *G*, Aerial hypha with a conidium at a somewhat later stage;  $\times 1000$ . *H*, Aerial hypha with three mature conidia, *a*, *b* and *c*;  $\times 500$ . *I*, Detached mature conidia, *a-y*;  $\times 500$ . *J*, Detached mature conidia, *a-k*;  $\times 1000$ . *K*, Conidium with an unsuccessful germ tube from which the protoplasm has been retracted;  $\times 1000$ . *L*, Mature zygosporangium with attached zygothores; *a*, pellicle of host;  $\times 1000$ . *M*, Collapsed pellicle of host animal surrounded with 19 mature zygosporangia, *a-s*;  $\times 500$ .

Fig. 3. *Acaulopage cercospora*; drawn with the aid of the camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of mycelium on which have been captured two *Amoebae*, *a* and *b*. *B*, Portion of mycelium with a captured *Amoeba*. *C*, *D*, Portions of hypha, each with a captured *Amoeba* and five denuded sterigmata. *E*, Portion of hypha with a captured *Amoeba*, three developing conidia, *a-c*, and a mature conidium *d*. *F*, Portion of hypha with a young conidium and two denuded sterigmata. *G*, Portion of prostrate hypha with 11 conidia, *a-k*, in place. *H*, Portion of prostrate hypha with three conidia in place. *I*, Portion of prostrate hypha consisting of an evacuated septate part with 7 denuded and evacuated sterigmata, and a living part with three sterigmata, one bearing a conidium in place.

Fig. 4. *Stylopape rhabdospora*; drawn with the aid of the camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of hypha whereon have been captured two animals, *a* and *b*, referred to *Amoeba similis*. *B*, Portion of hypha with a captured animal largely depleted of protoplasm. *C*, A specimen of *A. similis* attacked by four adhering conidia. *D-J*, Conidiophores: *E*, *F*, *J*, with all spores attached; *D*, partly denuded; *G*, *H*, *I*,

wholly denuded. *K, a-g*, Detached conidia. *L*, Two mature zygosporangia, *a* and *b*, each formed from union of a zygosporangium arising from a mycelial filament with a zygosporangium arising from a conidium. *M*, Another zygosporangium of like origin.

Fig. 5. *Zoopage atractospora*; drawn with the aid of the camera lucida at a uniform magnification;  $\times 1000$  throughout. *A, B*, Portions of mycelium, each with a captured *Amoeba*. *C*, Portion of mycelium with a captured *Amoeba, a*, and a mature chain of conidia, *b*. *D*, Portions of mycelium with a captured animal penetrated by two haustoria, *a* and *b*, and with a sterigma, *c*, bearing a bifurcate basal conidium. *E*, Portion of mycelium with one sterigma, *a*, bearing a growing aerial filament, and another, *b*, bearing a mature chain of conidia. *F*, Portion of hypha with a growing conidiiferous filament. *G*, Portion of mycelium with a captured animal, *a*, and an immature sexual apparatus, *b*. *H-J*, Immature sexual apparatus, all zygosporangia arising from mycelial filaments. *K, L*, Immature sexual apparatus, one of each pair of zygosporangia arising from a conidium. *M-R*, Mature sexual apparatus. *S, a-y*, Detached conidia.

Fig. 6. *Zoopage atractospora*; drawn with the aid of the camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of submerged mycelium and a specimen of *Amoeba striata* captured thereon. *B*, Portion of aerial filament consisting of three axial components *a, h* and *i*, together with a young branch made up of the components, *b-g*, and a short chain of separated mature conidia, *j-l*. *C-H*, Portions of mature conidial chains. *I*, a branched conidium. *J*, A branched conidium, the part *a* perhaps still to be separated from the part *b*. *K-T*, Detached conidia.

Fig. 7. *Zoopage cladosperma*; drawn with the aid of the camera lucida at a uniform magnification;  $\times 1000$  throughout. *A*, Portion of a vegetative hypha with a captured *Amoeba, a*; together with a sexual branch on which two immature zygosporangia, *b* and *c*, are in process of development. *B*, Portion of hypha with a chain of mature conidia. *C, a-o*, Detached mature conidia. *D*, Portion of hypha with zygosporangia developing on the sexual branches, *a* and *b*. *E*, Portion of hypha with a zygosporangium developing on a sexual branch. *F*, A fully grown but immature zygosporangium. *G-J*, mature sexual apparatus with portions of mycelium showing attachments.

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXIV. CHLOROCIBORIA

FRED J. SEAVER

(WITH 2 FIGURES)

The writer is proposing the above new name to replace *Chlorosplenium* as ordinarily used and for the following reasons:

Fries proposed the name *Chlorosplenium* based on *Chlorosplenium Schweinitzii* (*Peziza chlora* Schw.), a very small sessile cup-fungus of a lemon-yellow color externally and with an olive-green hymenium. The species is very common on hard wood throughout North America. Later DeNotaris, although he had never seen the type species, took up the name *Chlorosplenium* of Fries and added *Chlorosplenium aeruginosum* and *Chlorosplenium versiforme*. The former species has come to be looked upon as the typical *Chlorosplenium* although Fries did not regard it as congeneric with *Chlorosplenium Schweinitzii* when the genus was established but left it in the genus *Helotium*. Clements and Shear designate *Chlorosplenium aeruginosum* the type of the genus, giving Fries credit for the combination although, so far as we know, Fries never treated this species as a *Chlorosplenium*.

Nannfeldt recognized the fact that *Chlorosplenium Schweinitzii* and *Chlorosplenium aeruginosum* are not congeneric and suggests that the latter be kept in the genus *Ciboria*. Believing, however, that these forms are sufficiently distinct, the writer proposes that they be treated under the new name indicated below.

The following is the writer's conception of the genus *Chlorociboria* and some of the forms which should be included therein. The form on spruce cones collected by Dr. Baxter in Michigan is of unusual interest since it seems to be the first record from America.

### 1. *Chlorociboria* nom. nov.

*Chlorosplenium* DeNot. Comm. Critt. Ital. 1: 376. 1864, not Fries 1849.

Apothecia stipitate or substipitate, reaching a diameter of 1 cm. or rarely as large as 2 cm., the stem usually about half as long as

the diameter of the apothecium, resembling *Ciboria* but color green or olivaceous; asci usually 8-spored; spores irregularly ellipsoid to vermiform, simple, hyaline; paraphyses slender, clavate.

Type species, *Elvela aeruginosa* Oed.

1. ***Chlorociboria aeruginosa*** (Oed.) Seaver, comb. nov.

*Elvela aeruginosa* Oed. Fl. Dan. 9: 7. 1770.

*Peziza aeruginosa* Pers. Obs. Myc. 1: 27. 1796.

*Helotium aeruginosum* Fries, Summa Veg. Scand. 355. 1849.

*Chlorosplenium aeruginosum* DeNot. Comm. Critt. Ital. 1: 376. 1864.

*Peziza aeruginescens* Nyl. Not. Fauna Fl. Fenn. 10: 42. 1869.

*Chlorosplenium aeruginescens* Karst. Myc. Fenn. 1: 103. 1871.

Apothecia gregarious, stipitate or sessile at first cup-shaped becoming expanded and subdiscoid with the margin slightly elevated, verdigris-green and producing a similar color in the wood on which it grows reaching a diameter of 5 mm.; hymenium plane or lighter and sometimes yellowish; stem darker scarcely exceeding in length one-half the diameter of the apothecium and about 1 mm. thick; asci clavate, reaching a length of 45–50  $\mu$  and a diameter of 3–4  $\mu$ ; spores 2-seriate or irregularly crowded narrow ellipsoid  $2\text{--}2.5 \times 5\text{--}7 \mu$  (rarely 10–120); paraphyses very slender, about 1.5  $\mu$  in diameter, scarcely enlarged above.

On dead wood.

TYPE LOCALITY: Europe.

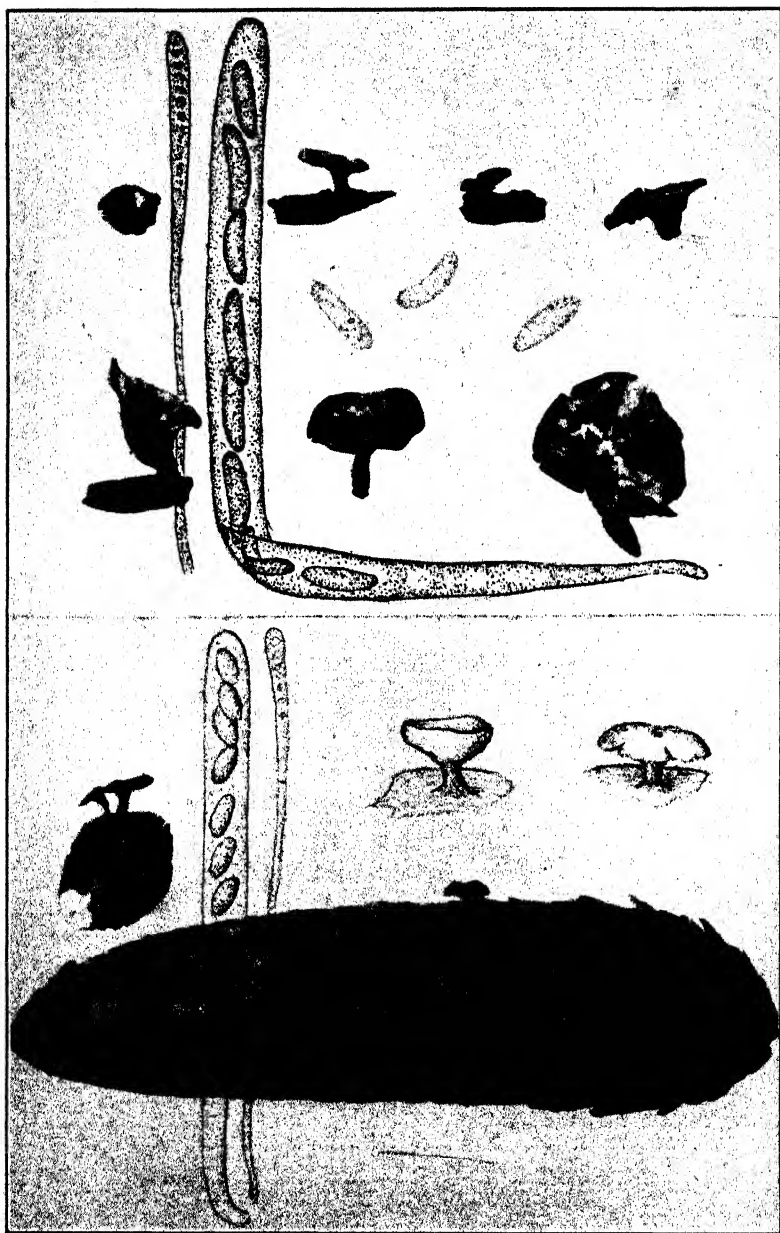
DISTRIBUTION: New York to Colorado, South to Mexico and the West Indies; also in South America, Europe, Asia, and Australia.

ILLUSTRATIONS: Boud. Ic. Myc. pl. 485; Fl. Dan. pl. 534, f. 2; Cooke, Austr. Fungi pl. 20, f. 158; Gill. Champ. Fr. pl. 88, f. 1; Grev. Scot. Crypt. Fl. pl. 241; Bull. Lab. Nat. Hist. 6: pl. 24, f. 1; Phill. Brit. Discom. pl. 5, f. 28; Rab. Krypt.-Fl. 1<sup>3</sup>: 749, f. 1–5; E. & P. Nat. Pfl. 1<sup>1</sup>: f. 155, H–L; Massee, Brit. Fungus Fl. 4: 156, f. 41–42; Sou. Engl. Fungi pl. 347.

EXSICCATI: N. Am. Fungi 987, 2047; Rav. Fungi Cav. 5: 40.

Some European authors recognize *Chlorosplenium aeruginescens* as distinct from *Chlorosplenium aeruginosum*. The writer has been unable to detect any difference of specific importance in the material which he has examined.





UPPER FIGURE. *Chlorociboria versiformis*.  
LOWER FIGURE. *Chlorociboria strobilina*.

**2. *Chlorociboria versiformis* (Pers.) Seaver, comb. nov.**

*Peziza versiformis* Pers. Ic. Descr. 25. 1798.

*Chlorosplenium versiforme* DeNot. Comm. Critt. Ital. 1: 376.  
1864.

*Helotium versiforme* Berk. Outl. Brit. Fung. 372. 1860.

*Coryne versiformis* Rehm in Rab. Krypt.-Fl. 13: 492. 1894.

Apothecia short-stipitate becoming expanded and subdiscoid or more often elongated on one side and often becoming subveriform; entirely light green or olivaceous, reaching a diameter of 1–3 cm.; stem short, usually not exceeding 4 or 5 mm., rather stout; asci clavate, reaching a length of 100–110  $\mu$  and a diameter of 5–7  $\mu$ ; 8-spored; spores irregularly long ellipsoid straight or curved 3–4  $\times$  9–14  $\mu$  occasionally becoming 1-septate; paraphyses strongly enlarged above where they reach a diameter of 2–3  $\mu$ , containing a greenish coloring matter.

On decaying wood.

TYPE LOCALITY: Europe.

DISTRIBUTION: New York and Massachusetts to Iowa and south to Mexico.

ILLUSTRATIONS: Boud. Ic. Myc. pl. 486; Bull. Lab. Nat. Hist. State Univ. Iowa 6: pl. 24, f. 2; Pers. Ic. Descr. pl. 7, f. 7; Berk. Outl. Brit. Fung. pl. 2, f. 6.

EXSICCATI: N. Am. Fungi 988.

**3. *Chlorociboria strobilina* (Alb. & Schw.) Seaver, comb. nov.**

*Peziza tuberosa strobilina* Alb. & Schw. Consp. Fung. 313.  
1805.

*Peziza versiformis livida* Alb. & Schw. Consp. Fung. 314.  
1805.

*Peziza Abietis strobilina* Alb. & Schw. Consp. Fung. 342. 1805.

*Chlorosplenium versiforme nigrescente-olivacea* Weinm. Fl.  
Ross. 467. 1836.

*Peziza ciborioides strobilaria* Nyl. Not. Fauna Fl. Fenn. 10: 36.  
1869.

*Cenangium strobilinum* Sacc. Fung. Ital. pl. 1306. 1883.

*Chlorosplenium lividum* Karst. Acta Soc. Fauna Fl. Fenn. II. 6:  
124. 1885.

*Peziza bulgaroides* Rehm in Rab. Fungi Eu. 1311; Hedwigia 9: 136. 1870.

*Rutstroemia bulgaroides* Karst. Myc. Fenn. 1: 105. 1871.

*Ombrophila strobilina* Rehm in Rab. Krypt.-Fl. 1<sup>3</sup>: 482. 1896.

*Ciboria strobilina* Bresadolae Boud. Ic. Myc. 4: 18. 1907.

Apothecia stipitate or sessile, at first concave, becoming expanded and subdiscoid or shallow cup-shaped, occasionally repand reaching a diameter of 1 cm. or rarely larger, brownish-black or with a slightly olive tint; hymenium similar in color to the outside of the apothecium; stem short scarcely exceeding one-half the diameter of the apothecium; slightly lacunose; asci clavate, reaching a length of 85  $\mu$  to 100 and a diameter of 5–7  $\mu$ ; spores irregularly ellipsoid 3–4  $\times$  7  $\mu$ .

On spruce cones.

TYPE LOCALITY: Europe.

DISTRIBUTION: Michigan; also in Europe.

ILLUSTRATIONS: Sacc. Fungi Ital. pl. 1306; Boud. Ic. Myc. pl. 480.

#### EXPLANATION OF FIGURES

Upper figure (1). *Chlorociboria versiformis*. Photographs of apothecia in various stages of development, about natural size; also drawings of ascus with spores and paraphysis. Photographs furnished by the Dominion National Museum, Canada.

Lower figure (2). *Chlorociboria strobilina*. Photograph of spruce cone with apothecia, about natural size; also one scale removed with apothecia. Upper right-hand corner, drawings of two apothecia, enlarged about two diameters; also drawing of ascus with spores and paraphysis. Photographed from material collected in Michigan by Dow V. Baxter.

## NOTES AND BRIEF ARTICLES

### THE MUSHROOM HANDBOOK

So many of the old mushroom books are out of print that the appearance of any new work on this subject is appreciated by mycophagists and mycologists. "The Mushroom Handbook" by Louis C. C. Krieger has recently appeared. This work was prepared at the State Museum in Albany, Dr. Krieger having previously worked with Dr. W. G. Farlow of Harvard University and Dr. Howard A. Kelly of Baltimore. The volume consists of 538 pages and is fully illustrated with halftone photographs and drawings and 32 colored plates beautifully done by Dr. Krieger. The first part of the book is devoted to a general discussion of the characteristics and habits of the fungi with directions for the growing of mushrooms. The latter part of the book consists of technical descriptions and popular notes on the various edible and poisonous species. Special attention is properly given to a consideration of the characteristics of the more poisonous species. There is, also, full discussion of common species which are safe for the beginner to use. The book is published by the Macmillan Company, New York City.—FRED J. SEAVER.

### BESSEY'S TEXT-BOOK OF MYCOLOGY <sup>1</sup>

Those of us who had the pleasure of using Professor Charles E. Bessey's "The Essentials of Botany" in college and of knowing him personally will be especially interested in the new "Text-Book of Mycology" by his son Ernst A. Bessey.

As indicated by the author, this text is intended as an introduction to the subject of mycology, where more technical works such as Gäumann and Dodge, Comparative Morphology of Fungi are impractical. The author also emphasizes the fact that this is a text-book of morphology and not of the physiology of the fungi. Since a work of this kind will do little more than "whet the ap-

<sup>1</sup> Published by P. Blakiston's Son & Co., Inc., 1012 Walnut Street, Philadelphia, Pennsylvania.

petites" of budding mycologists, rather complete bibliographies by the most outstanding authors on the various groups are included at the end of each chapter.

The writer is not actively engaged in teaching of mycology but has heard very favorable reports from those who have used the text-book in their class work. This volume has been out nearly a year and it had been hoped that a more extended review might be presented by some active teacher of mycology. In the absence of this, the present announcement will suffice. The text-book is very fittingly dedicated to the memories of two great teachers, his illustrious father, Charles E. Bessey, and Georg Klebs.—F. J. SEAVER.

#### AN ANCIENT ROMAN TOADSTOOL CARVED IN STONE

In his article "An ancient Roman toadstool carved in stone" in MYCOLOGIA (21: 143-144, 1929). John W. Harshberger writes about a visit to the ruins at Tingad (Algeria), a town founded by the legate, P. Munatius Gallus, by order of the Roman emperor Trajan about 100 A.D. In the chief market place Mr. Harshberger found two large blocks of stone, one of which was "characterized by a design of *Acanthus* leaves surrounding a centrally placed stone toadstool, carved so that the gills and related stipe with basal volva are clearly shown. The stone figure has been identified as a toadstool, although with its volva, it probably represents some poisonous, pileate, lamellate, fleshy toadstool known to the ancient artist, who designed the architectural ornamentation of the Tingad market place. Do we not have in this stone carving the earliest known representation of a fleshy, gill-bearing fungus, dating back to the second century A.D.?" (Harshberger, l.c.)

When I saw the excellent photograph in MYCOLOGIA I identified the stone figure as *Volvaria speciosa* (= *V. gloiocephala*).

For a long time in Europe this fungus had been considered very poisonous, although Persoon stated that it was edible. Herrfurth in Germany, and Bresadola in Austria, ate it during the Great War, and Dearness (*Volvaria speciosa*, MYCOLOGIA 23: 152-153, 1931) in America in 1930. The examinations of Mr. Gauthier, Menier, and Monnier have proved the fungus to be

edible. According to R. Maire's report the fungus is offered for sale in large quantities at the markets in Algeria. By the carving in stone the ancient Roman artist wanted to show a well-known merchandise, and not a poisonous fungus. I am sure the ancient Romans did not consider a pileate, lamellate, fleshy toadstool with volva to be poisonous, because their favorite mushroom, the *Amanita caesarea*, is a pileate, lamellate, fleshy fungus with volva. —HEINRICH LOHWAG, *President, Austrian Mycological Society.*

#### THE SYNONYMY OF *BOTRYTIS RILEYI* FARLOW

*Botrytis Rileyi*, the fungus producing the cholera disease of insects was described by Farlow in 1883 from material on larvae of *Plusia Brassicae* (*Autographa Brassicae*).<sup>1</sup> The spores were described as borne in whorls and catenulate and the fungus therefore can not be referred properly to the genus *Botrytis*.

In 1903, Maublanc<sup>2</sup> established the genus *Nomuraca* which he named in honor to Nomura who sent him specimens of *Pionea forficalis* affected by the fungus, which he called *Nomuraca prasina*. The generic description shows this fungus to be a *Spicaria*, a fact recognized by Sawada in his Descriptive Catalogue of the Formosan Fungi (1919, p. 606), the new combination being *Spicaria prasina* (Maubl.) Saw.

Petch, in one of his papers on entomogenous fungi<sup>3</sup> discusses *Botrytis Rileyi* and its possible identity with *Spicaria prasina* and states that the fungus on specimens of *Anticarsia gemmatilis* sent him from Florida is *Spicaria prasina*. However, mycologists in the United States have determined this fungus as *Botrytis Rileyi*.

Clements and Shear in their Genera of Fungi (1931, p. 203) separate *Nomuraca* and *Spicaria* solely on the character of their habitat, *Nomuraca* being described as entomogenous and *Spicaria* as phytogenous. This distinction does not appear to have been generally recognized, Petch and other mycologists having assigned a number of entomogenous forms to the genus *Spicaria*. In view of the close morphological affinities of *Botrytis Rileyi* with the

<sup>1</sup> Report of the U. S. Comm. Agr., p. 121, 1883.

<sup>2</sup> Maublanc, A. Sur quelques espèces nouvelles de champignons inférieurs. Bull. Soc. Myc. Fr. 19: 295-296. 1903.

<sup>3</sup> Petch, T. Entomogenous Fungi. Trans. Brit. Myc. Soc. 11: 264. 1926.

genus *Spicaria* and the priority of the specific name, this fungus should be designated as ***Spicaria Rileyi*** (Farl.) Charles comb. nov.—VERA K. CHARLES.

#### ATRACTOBASIDIUM

Under the name *Atractobasidium corticioides* Martin appeared the first recognizable description<sup>1</sup> of a heterobasidiomycetous fungus strikingly characterized by fusiform basidia divided by three obliquely transverse, intersecting septa. Almost immediately, as a result of what the late C. G. Lloyd was wont to call the Sacred Principle of Priority, it was found necessary to re-name this fungus *A. Grandinia* (Rick) Martin.<sup>2</sup> It now appears that a third name must in turn replace the second.

From examination of authentic material in the Farlow Herbarium of *A. corticioides* Martin, *Platyglora Grandinia* Rick, *Patouillardina cinerea* Bres., *Protograndinia cinerea* Rick (Egataea 18: 213), and a presumably unpublished species assigned by Rick to this genus, it is clear that all are examples of the same organism and must be known by the oldest name, *P. cinerea* Bres. The specimen of *Patouillardina cinerea*, collected by Rick in Brazil and communicated by Bresadola to Patouillard, is presumably a portion of the material discussed by Rick<sup>3</sup> and by Bresadola<sup>4</sup> and figured by the latter.<sup>5</sup> It is true that these discussions of *Patouillardina* completely fail to include any of the essential characters; and that the published figure, a duplicate of a sketch on the packet containing *Patouillardina* in Patouillard's herbarium, is quite insuperably delusive. It is true that from these accounts and illustrations even Rick was unable to recognize the fungus in his own later collections. Nevertheless, since no code of nomenclature permits the consigning of a name to oblivion on the mere grounds that it is founded exclusively on error, *Patouillardina cinerea* Bres. must stand until it is legally superseded by a name even longer buried and forgotten.—D. P. ROGERS.

<sup>1</sup> Torrey Bot. Bull. 62: 339-343. fig. 1, 2. 1935.

<sup>2</sup> Mycologia 28: 198. 1936 (Apr.).

<sup>3</sup> Brotéria 5: 7. 1906.

<sup>4</sup> Ann. Myc. 18: 52. 1920.

<sup>5</sup> E. & P. Naturl. Pflanzenfam. 2 Aufl. 6 Bd., fig. 87C.







BERNARD O. DODGE, PRESIDENT 1935





# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVIII SEPTEMBER-OCTOBER, 1936 No. 5

## FACULTATIVE AND OBLIGATE HETERO- THALLISM IN ASCOMYCETES

B. O. DODGE<sup>1</sup>

(WITH 2 FIGURES)

You have heard the Secretary's report on the 1935 mycological foray. I am sure the Society is very grateful to Professors Fitzpatrick, Whetzel, and their associates, for their efficient work in organizing last summer's meeting. The 1934 foray was held at a camp site in the midst of good collecting grounds. This year at Cornell University we had the use of one of the best equipped botanical laboratories in the country. As between the two situations I should prefer a location where we could display our collections in such a way that every one could see what the others had gathered. We all profited from this advantage at Cornell. It does not need to be a large laboratory, and the equipment need not be expensive. I hope that in the near future we may be able to arrange a summer meeting in the middle west. Personally, I should like to have one in Wisconsin so that I could take you over some of my old collecting grounds.

Very few of the members of our Society realized when they selected their presiding officer for the past year, that they were choosing a mycologist of the old school. If collecting and publishing a list of 550 species of fleshy fungi make one an old time mycologist, then I am one.

<sup>1</sup> Address of the retiring President of the Mycological Society of America, St. Louis, December 31, 1935.

[MYCOLOGIA for July-August (28: 297-398) was issued August 1, 1936]

Most persons are more or less interested in mushrooms and toadstools. An early interest in this work naturally had its effect on my high school students so that the teaching of botany and physics became much easier. The boys from the rural districts near Algoma, Wisconsin, were especially enthusiastic, bringing in many specimens to be named. We had our favorite sphagnum bogs and tamarack swamps where we could always find *Boletus spectabilis*, *B. elbensis*, *B. Clintonianus*, *Boletinus palustre* and other interesting boletes in season. Unless you have been in that State you have probably never collected *Boletus sphaerosporus*. It has a rather repulsive appearance when mature, due to the purplish slime which covers the tough leathery veil and the upper part of the stipe. The flesh is solid so that when fried or broiled it makes a good substitute for beef steak. We also tested other species with bad reputations. One of my worries on these high school forays was the habit the boys had of toasting and eating any mushroom they might find. That there were no cases of poisoning in that community must have been due to the scarcity of the deadly poisonous species rather than to our expert knowledge of the species.

One misty morning in September when I was still much of a novice, we had collected two curious pinkish bodies about the size of a hen's egg, partly buried at the base of a stump. They were left in the damp paper sack on the laboratory table for an hour or so while I attended to other school duties. Upon return later instead of our two prized egg-like specimens we found sticking out through the paper two foul-smelling objects, the like of which we had never seen or heard of before. We thought that some one had switched specimens as a practical joke on the teacher. It was not until about two weeks later that we discovered that the joke was really on myself because of my ignorance of the ways of some of these fleshy fungi.

Strange as it may seem, if it had not been for Dr. Seaver of The New York Botanical Garden, I would very likely have continued taxonomic mycological work after coming to New York. He suggested as a problem for a thesis a taxonomic study of the Ascobolaceae. It was soon evident that, while there was much to be learned about species as they developed on their natural

substrata in damp chambers, it was very desirable to grow them also in pure cultures where their ascocarpic primordia could be studied. Sex is always such an interesting study that when one starts looking at ascogonia, trichogynes, spermatia and other reproductive structures of this fascinating group he is apt to forget all about the monographing of his genus.

I recall the great excitement with which, as an isolated country-town high school principal, I opened the packet which contained the first book on mushrooms which I had ever seen. The odor that came out when the book was opened, perhaps the odor of printer's ink retained in the newly printed book, has remained in my memory. I was impressed by the fine appearance of the book and noted how the shining white paper took so well the beautiful photographs of various types of mushrooms. If you know this book you can imagine how the pictures of *Dictyophora duplicata* and *Phallus impudicus* cleared up that mystery of the eggs in the paper sack. The author points out that these phalloids grow so fast as they hatch out that it is very difficult to get good photographs.

As I read the book through the night, I was further impressed with the clear and simple yet highly scientific language that was used in discussing the various topics. The selection of species for consideration was also very fortunate as we had no trouble in recognizing from the descriptions any number of forms that we had collected and studied without the help of any published works on mushrooms. Little did I think at that time of ever meeting the author of that book, and much less that I would, within a few years, be sitting in a hotel lobby in Philadelphia in violent argument with him on the merits of ascogonia, trichogynes and spermatia as evidence of a relationship between the ascomycetes and the red algae. The discussion was proceeding so violently that I felt something had to be done, and took the first opportunity to calm my opponent. I said "Why, Professor Atkinson, neither one of us knows anything about where the ascomycetes came from. I simply brought together the best evidence I could find in support of one view. I believe you did the same for your side. You even left out one of the best pieces of evidence in favor of your view." It was to his credit that,

after remaining silent a moment, he responded, "I guess you are right, Dodge, what we really need is more information regarding sex and reproduction in these fungi."

It is with the same spirit that I presume to speak today on heterothallism in the ascomycetes. Our disagreements as to the terminology are probably due to inertia as much as to our lack of knowledge concerning the processes involved in reproduction. Until much more information is obtained we must go on using terms more or less inconsistently and loosely. It was hoped to arrange a symposium or round-table discussion for this hour on the program. Each one of us could have been given the opportunity to formulate definitions of such terms as sex, maleness, femaleness, heterothallism, homothallism, hermaphroditism, incompatibility, sterility, hybrid, diploid and spermatization. Evidently we are not yet ready for such a program.

Discussing ascomycetes, can we use the terms heterothallism and homothallism in the sense in which they were first used by their author? Blakeslee found a very definite bipolar sex-reaction existing not only between races of certain species, but also between species from different genera of the Mucoraceae. It was convenient at that time to call one race of *Phycomyces* + because it produced more sporangia than did the other tester which he referred to as -. Whether this sex linked vegetative distinction holds throughout the various genera is not important. The important thing for purposes of evolution would be that +/— races have a genetic differentiation. It is also important not to confuse +/— genetic differences in heterothallic species with phenotypic cell differentiation in case of hermaphroditic species. This point is being discussed this afternoon on another program.<sup>2</sup> We might well agree with Kniep who, in reviewing the work of Blakeslee and Burgeff on heterothallic races of the Mucoraceae, concludes that, while there are a number of contradictions and apparent inconsistencies that must be explained away, on the whole one must believe that in the "dioecious" species sexual reaction has a chromosomal basis.

<sup>2</sup> Reproduction and inheritance in ascomycetes. Science II. 83: 169-175. 1936.

## TYPES OF ASCOMYCETES

Regarding the potency of species to reproduce we may roughly classify them in four or five groups.

Group 1. Certain ascomycetes like *Pyronema*, *Pleospora*, *Ascodesmis*, and probably all ascocarpic species of *Penicillium*, to cite a few well known examples, have all of their inheritance carried in a single uninucleate totipotent ascospore. Whether or not one finds differentiated organs in the primordia we may call such species homothallic comparable to *Sporodinia* and *Zygorhynchus* of the Mucoraceae. In homothallic ascomycetes we must expect certain races to be more fertile than others under our cultural conditions. Some students seek to explain sectoring, saltations or mutations in plate cultures of *Fusarium*, *Helminthosporium*, *Aspergillus* and others on the basis of heterocaryosis. Naturally if somatic mutations occur in one's cultures of a haploid mycelium, one could refer to the growth as a whole as heterocaryotic. We want to know first whether the individual cells are uninucleate or multinucleate. The ascospore of *Pyronema* is uninucleate but the cells of the mycelium are multinucleate, not heterocaryotic. Simply because one sees hyphal anastomoses is no justification for assuming that a heterocaryotic condition arises due to hyphal fusions between genotypically different races. We must have proof that there is a nuclear migration or that regeneration branches containing a mixture of nuclei actually grow out from the cell unions.

Great advances in our knowledge of the fungi have resulted from the practice of culturing from single spores. To date a large majority of ascocarpic species have proved to be homothallic.

Group 2. Holding to Blakeslee's original idea we should imply by heterothallism that in ascomycetes all races of a species fall into two main groups as to their sex-reactions. We obtain ascocarps only when two races of opposite sex are mated. *Ascobolus magnificus*, *Neurospora sitophila*, *Sclerotinia Gladioli*, *Bombardia lunata*, and *Humaria granulata* are good examples. Their asci are 8-spored, each spore contains a single nucleus at its origin, and for any pair of simple mendelian factors there will be found on analysis of all eight races from an individual ascus a 1 : 1 segregation ratio.



The list of strictly heterothallic species is slowly growing. Certain species like *Penicillium luteum* and *Fusarium moniliforme*, reported to be heterothallic would very likely prove to be homothallic on further examination.

Group 3. The most interesting of all ascomycetes to me are those species like *Neurospora tetrasperma*. Here the asci are normally 4-spored, each spore carrying at its origin two nuclei of opposite sex. *Neurospora Toroi*, *Pleurage anserina*, *P. taenioides* and *Gelasinospora tetrasperma* have a similar organization. The cytology of *Neurospora tetrasperma* has been worked out to show the unique mechanism by which each spore is provided with the two nuclei of opposite sex. Disarrangement or faulty orientation of the nuclear spindles sometimes results in cutting out one or more uninucleate ascospores in an ascus. Such spores are invariably unisexual in their reactions.

Group 4. We have species like *Glomerella cingulata*, and *G. Lycopersici* where occasionally races, according to Edgerton and Hüttig, are totipotent and thus produce fertile ascocarps, while others are either self-sterile, or produce only an occasional fertile fruit body. Rarely one finds, as first shown by Edgerton over twenty years ago, a pair of races, one "hermaphroditic" and the other unisexual, or at least less fruitful, which will, when grown from opposite sides of a plate culture form a row of ascocarps along the line where the mycelia meet. Edgerton referred to such pairs as  $+/-$  races, although both may mature some ascocarps with spores. Hüttig unaware of Edgerton's work on the subject calls the fertile races hermaphroditic and the sterile races male. According to him one may have male "sclerotia" (incipient perithecia). Edgerton made a good start in trying to analyze the eight spores from a single ascus from his matings, but it yet remains to carry such a study to a successful conclusion.

Group 5. A large number of imperfect fungi must have ascocarpic stages in nature. Whether a species can lose permanently its inheritance to produce ascocarps is a question that can never be settled. Someone once remarked to me that *Monilia sitophila* had evolved such an efficient conidial apparatus for asexual reproduction that it no longer needed ascocarps, so that they have dropped out of the life cycle. One author believes that

ascocarps of this species are not found in nature because of certain sterility factors in wild types prevent fertilization in races heterocaryotic following hyphal fusions. A study, not only of the literature but of wild types themselves discloses the fact that ascocarpic stages of all six species of *Neurospora* are very commonly produced in nature. The trouble is that persons who have found the perithecia did not recognize the connection between the monilioid and the ascocarpic stage. They did not appreciate the fact that some species are heterothallic and that in all species the ascospores usually require a certain heat-treatment to stimulate them to germinate.

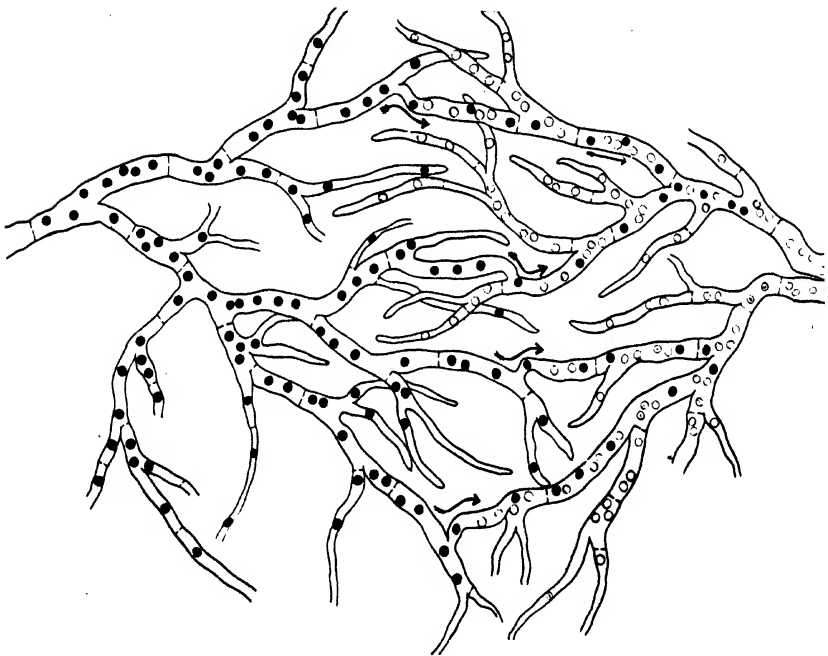


FIG. 1. Diagram showing how race S9 mycelium of *Neurospora tetrasperma* becomes miktohaplontic by nuclear migrations from S1.

Having briefly noted how one might group species of ascomycetes as to their inherent ability to fruit sexually, we may turn to a comparison of species in our Groups 2 or 3.

Just what is the fundamental difference between the 8-spored heterothallic *Neurospora sitophila* and the 4-spored totipotent

*N. tetrasperma*? Is the difference merely in the orientations of their nuclear spindles in the asci, and is this orientation a function of ascus shapes and dimensions, or is it a function of mutual sexual attractions and repulsions? An answer to these questions must distinguish exactly between what we have called facultative and obligate heterothallism. Not knowing the cytology of *N. tetrasperma* one must classify it as homothallic. Knowing that its mycelial cells are normally heterocaryotic and bisexual, the term homothallic is not applicable at all. The term facultative heterothallism was suggested to cover species like *N. tetrasperma* where one can separate mechanically the two component unisexual elements. For example, our tester races C4 and C8 were isolated by plating out small unisexual conidia. One could in this way obtain a collection of strains which would be of two sorts as to their reactions when paired.

Experiments with this species as well as with *Gelasinospora tetrasperma* and *Pleurage anserina* prove that whenever one grows two mycelia of opposite sex together from opposite sides of a plate culture anastomoses occur and these are followed by variable amounts of nuclear migrations.<sup>3</sup> We have recently repeated the experiments with our races Gel. 1 and Gel. 5. Every one of the 84 1-tip cultures obtained in the manner described in the paper just cited produced mycelia which gave rise to fertile perithecia. Furthermore 17 of the isolates were obtained from a transplant taken from the underside of the agar. This proves that nuclear migrations are not confined to surface hyphae.

Cook and Swingle<sup>4</sup> distinguished very clearly between those cells or phases in fungi carrying fused nuclei and those such as occur in *Agaricus* and *Puccinia* where the mycelial cells contain two unfused nuclei each. For the latter type they coined the term apalogamic phase.

Strasburger<sup>5</sup> proposed the terms haploid and diploid generations to apply particularly to phases in which the nuclei contain the single and double number of chromosomes respectively. He emphasized in several of his later papers the difference between

<sup>3</sup>The mechanics of sexual reproduction in *Neurospora*. *Mycologia* 27: 418-438. 1935.

<sup>4</sup>Evolution of cellular structures. *Bur. Plant Ind. Bull.* 81: 1-20. 1905.

<sup>5</sup>Histologische Beiträge zur Vererbungsfrage. *Jahrb. Wiss. Bot.* 42: 1-71. 1905.

diploid cells and binucleate cells. The geneticists have also firmly fixed the terms triploid, tetraploid and polyploid in the literature as denoting relative chromosome numbers. *Neurospora tetrasperma* cells normally contain two kinds of nuclei as to their sex reaction but they are not diploid; they are multinucleate but not polyploid; they are heterocaryotic and miktohaplontic as Kniep used the latter term; they are bisexual in their reaction. Unisexual races of this species could be heterocaryotic and yet not be miktohaplontic. We should refer to the binucleate phase of a rust or mushroom as dicaryotic rather than diploid. Buller's term "diploidization" has a fine ring to it nevertheless.

If, as the result of hyphal anastomoses, nuclei of one or more kinds migrate from one mycelium into another of opposite sex so that there is a commingling of these several sorts one has not thereby hybridized two unisexual races (FIG. 1). It is only when two nuclei, one from each parent race, fuse in the ascus that one obtains a hybrid. Asci are the only structures in the whole life cycle that can express true hybridity. If one proposes the term prohybrid for a mycelium whose nuclear content has been added to through hyphal fusions and nuclear migrations, well and good. Hybridization is accomplished only when those nuclei fuse in an ascus or a basidium.

When races S1 and S9 are opposed in a plate culture, nuclei from S1 usually migrate down the lines of S9 hyphal growth. As pointed out elsewhere the direction and extent of this migration may depend not only on cultural conditions but possibly on the sexual attractions existing naturally between the two kinds of nuclei. One sees (l.c.<sup>3</sup> *pl.* 40, *A*) streaks of perithecia along certain coarse hyphae. It may be that the opening or pore present in a cross wall is more or less proportional to the diameter of the hyphal cell. In fully mature or aged hyphae the pores must be smaller or more nearly closed up. This could account for the difficulty one has in "spermatizing" old incipient perithecia. In certain matings (l.c.<sup>3</sup> *pl.* 40, *B*) nuclear migrations in one direction are limited to a certain band. The width of this band increases very slowly. One can not say that there is no overgrowth or mingling of hyphae, but under well regulated cultural conditions and choice of races one can easily prove

nuclear migrations where it is not possible to find evidence for a mycelial overgrowth.

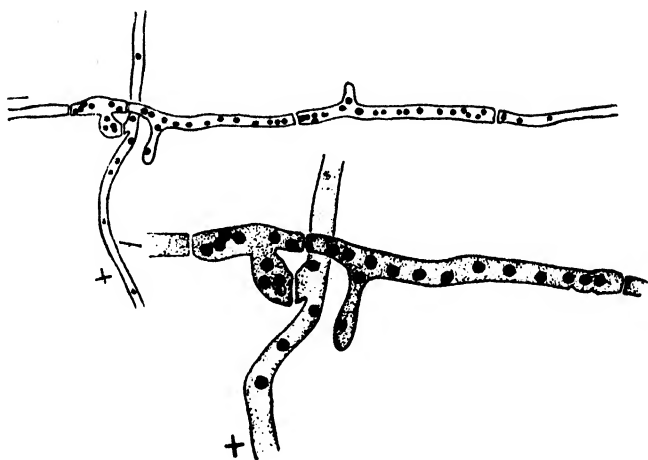


FIG. 2. Local miktohaplontic condition in heterothallic *Neurospora sitophila* resulting presumably from nuclear migrations through pores in the cross-walls. After Schönefeldt.

Köhler<sup>6</sup> working with mixtures of germinating monilioid conidia of *N. sitophila* tried in vain to unite vegetatively races of opposite sex. On the other hand Schönefeldt,<sup>7</sup> working with hyphal growth instead of germinating conidia, seems to have shown that although she saw no openings or other evidence of nuclear migrations where the  $+/-$  hyphae came into contact, in the tangle in some way a nuclear migration does occur very locally and this results in the development of fertile perithecia at that spot (FIG. 2). In our own work, reported elsewhere,<sup>3</sup> we were not able to prove in a limited number of experiments, nuclear migrations in mixed cultures of *N. sitophila*. One sees occasionally individual hyphae from one race growing along under the mycelium of the opposite sex. This would certainly provide opportunity for fertilization in various parts of a culture without the necessity for extensive nuclear migrations in wholly vegetative growth.

We have seen that in the facultatively heterothallic ascomy-

<sup>6</sup> Zur Kenntnis der vegetativen Anastomosen der Pilze. *Planta* 10: 495-522. 1930.

<sup>7</sup> Entwicklungsgeschichtliche Untersuchungen bei *Neurospora tetrasperma* und *Neurospora sitophila*. *Zeits. Induk. Abstam. Vererb.* 69: 193-209. 1935.

cetes, *Neurospora tetrasperma*, *Pleurage anserina*, and *Gelasinospora tetrasperma*, there is from the time the spores are delimited up to nuclear fusions in the asci some sort of attraction which tends to hold nuclei of opposite sex together in the same cells. This enables the totipotent mycelia to develop perithecia directly, that is without outside fertilization or spermatization by criss-crossing. If isolated unisexual races are grown together nuclear migrations follow anastomoses. This has been proved for cases when the unisexual races concerned were of *opposite* sex in their reactions. No one has as yet proved, however, that there are interchanges of nuclei when the races are of the *same* sex but differ in other genetic factors. When such experiments are performed we may have an answer that will throw further light on the nature of sex in these fungi; we shall know whether nuclear migrations result from something in addition to natural protoplasmic streaming.

As I see it today the main difference between facultative and obligate heterothallism is that in the former nuclei of opposite sex have a certain rather strong attraction for each other throughout the life cycle. This attraction is responsible more than anything else for the peculiar orientation of the nuclear spindles in the asci. In obligate heterothallic species like *Neurospora sitophila* this attraction is strong only at a certain stage of maturity. This would mean that if one should succeed in any way in obtaining a miktohaplontic mycelium, one in which the cells contain nuclei of opposite sex, he would obtain, on isolating hyphal tips from regenerated growth, only unisexual mycelia because of the strong tendency to split up. It remains to prove by careful experiments whether this can be done or not. If we assume that there is a sort of sexual attraction, the resultant direction the migrating nuclei take may depend on the relative sizes of the cross-wall pores of the two races. This does not exclude the possibility that the cytoplasm may also be a factor.

Of the five facultative heterothallic species which I have studied *Pleurage taenioides* and *P. anserina* seem to be less fixed as to their miktohaplontic nature. The basis for this conclusion is given in another place.<sup>8</sup>

<sup>8</sup> Spermatia and nuclear migrations in *Pleurage anserina*. *Mycologia* 28: 284-291. 1936.

## STUDIES IN THE GENUS MYCENA. III.<sup>1</sup>

ALEXANDER H. SMITH

(WITH 3 FIGURES)

During the fall of 1935, with the aid of a grant from the Faculty Research Fund of the University of Michigan, the writer studied intensively the species of *Mycena* occurring along the coast of Washington, Oregon and northern California. After establishing head quarters at Lake Crescent, about twenty miles west of Port Angeles, Washington, trips were made to the Cape Flattery region, Lake Ozette, La Push, and up the Hoh River as well as back into the mountains around Olympic Hot Springs and Sol Duc Hot Springs. With the onset of cold weather during the first part of November, the writer moved south to the sand dune region between Florence and Reedsport, Oregon. During the first part of December the third and final location was made at Trinidad, California, a small hamlet a short distance north of Eureka. The weather for the most part was exceptionally cold and dry throughout the entire coastal area.

The species in the *Mycena* flora which were most abundant were *Mycena tenax*, described below, *M. aurantiomarginata* (Fries) Quél., *M. galopoda* (Fries ex Pers.) Quél. and *M. amicta* (Fries) Quél. Other very interesting species are: *Mycena juncicola* (Fries) Gill., *M. scabripes* Murr., *M. elegans* (Fries ex Pers.) Quél. and *M. trachyspora* Rea. The last three were rather abundant under pure stands of redwood, a situation which was a distinct surprise to the writer.

In addition to the western material, certain species and collections from central and eastern United States are also included at this time. The collection numbers and the photographs are the writer's unless otherwise stated. The specimens have been deposited in the Herbarium of the University of Michigan.

The writer is particularly grateful to Prof. S. M. Zeller of

<sup>1</sup> Papers from the Department of Botany and the Herbarium of the University of Michigan, no. 568.

Oregon State Agricultural College, Corvallis, Oregon, for helpful suggestions and for courtesies extended to him while he was located in Oregon, and to Mr. Harold E. Parks of Trinidad, California, whose intimate knowledge of the northern coastal area of California contributed in a very large measure to the success of the writer's visit.

***Mycena nodulosa* sp. nov. (FIG 3: 1-3).**

Pileus 1-3.5 cm. latus, tenuis, conico-campanulatus, demum umbonatus, fuscus vel griseus, demum pallidus, canus demum politus; lamellae latae, confertae, rufo-maculatae, adnexo-adnatae, pallidae; stipes 6-10 cm. longus, (1)2-3 mm. crassus, radicans (4-8 cm.), dense pubescens, dorsum fuscus, sursum pallide griseus; sporae globosae, hyalinae, 6-7.5  $\mu$ , nodulosae; cystidia 60-80  $\times$  10-12  $\mu$ , fusoido-ventricosa, leva vel incrassata; superficies pilei e cellulis basidiiformibus unistratosis constans.—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Lake Crescent, Washington, Oct. 6, 1935, A. H. Smith, *n.* 2099.

Pileus 1-3.5 cm. broad, conic, campanulate or expanded and with a conic umbo, surface at first hoary from projecting cystidia and appearing very finely pubescent under a lens, soon glabrous, moist, striate to the disk, "fuscous"<sup>2</sup> to black on the umbo, margin dark or light watery gray, fading to a pallid sordid gray; flesh soft and pliant, pale fuscous, very thin, taste and odor not distinctive, in extreme age sometimes staining reddish brown; lamellae broad, moderately close, deeply adnexed to broadly rounded and depressed adnate, whitish to glaucous gray, spotted brownish in age; stipe 6-8 cm.  $\times$  (1)2-3 mm., with a pseudorhiza 4-8 cm. long, fuscous at first, becoming pale gray to whitish above, evenly covered by a white pruinose-pubescent covering of cystidia, pliant, with a sharply differentiated cartilaginous rind, hollow; spores globose, hyaline, 6-7  $\mu$ , with aculae 2-3  $\times$  1.5  $\mu$  scattered over the surface, staining pale yellowish with iodine in chloral hydrate; cystidia numerous on sides and edges of the gills, 60-80  $\times$  10-12  $\mu$ , usually with incrustated apices, unbranched, fusoid-ventricose; basidia four-spored; pileus trama corticated by a pallisade layer of clavate basidia-like cells measuring 18-22  $\times$  8-9  $\mu$ , elongated cystidia 100-150  $\times$  8-10  $\mu$  projecting from this layer at intervals, the remainder of compact floccose-filamentose tissue.

This species is easily distinguished by the pallisade layer of small basidia like cells forming the surface of the pileus. Because

<sup>2</sup> All names of colors within quotation marks are taken from R. Ridgway, Color Standards and Color Nomenclature, 1912.



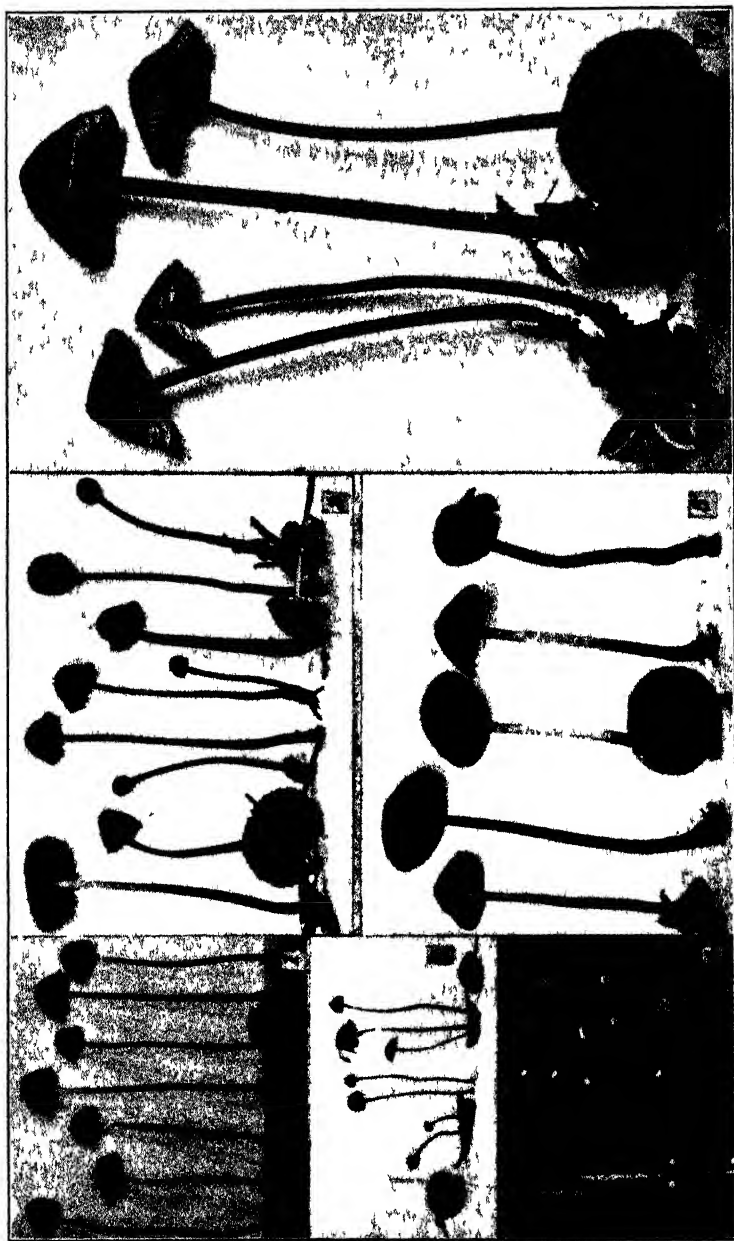


FIG 1 1, *Mycena cinerella* Karst,  $\times 1$ , 2, *Mycena capillariipes* Peck,  $\times 1$  3, *Mycena oregonense* Smith,  $\times 1$  4, *Mycena juncicula* Fries,  $\times 1$ , 5, *Mycena aurantimarginata* Fries  $\times 1$ , 6, *Mycena trachyspora* Rea,  $\times 1$

of the collapsible nature of these cells they are difficult to demonstrate in dried material. The incrustated cystidia are very like those of *Mycena Cooliana* Oort which is said to be without a pseudorhiza. From *Mycena Meulenhoffiana* Oort it differs in its tough rather flexible stipe and incrustated cystidia. Judging from the description, *Mycena bryophila* Voglino is readily separable because of its glabrous stipe.

***Mycena oregonensis* sp. nov. (FIG. 1: 3).**

Pileus 2–10 mm. latus, obtuse conicus vel convexus, glaber, luteus, fragilis; lamellae distantes vel subdistantes, angustae, late adnatae, brevissime angulatum decurrentes, acie lutea; stipes 1–3 cm. longus, 0.5–0.7 mm. crassus, pileo concolor; sporae  $7-8 \times 2.5-3 \mu$ , anguste ellipsoideae, apice acuminatae; cystidia fusoido-ventricosa, leva,  $35-45 \times 10-12 \mu$ .—Specimen typicum in Herb. Mich. conservatum: Legit prope Lake Tahkenitch, Oregon, Nov. 21, 1935, A. H. Smith, n. 3586.

Pileus 2–10 mm. broad, obtusely conic to convex, faintly hoary at first, soon polished, moist, "capucine yellow" on the disk, "deep chrome" toward the faintly striate margin, opaque after loosing moisture, colors hardly fading, edge entire or somewhat broken; flesh thin, brittle, odor and taste not distinctive; lamellae distant to subdistant, at first sometimes appearing close, narrow, broadest at point of attachment, adnate, developing a rather distinct decurrent tooth in age, "massicot yellow" or appearing whitish, edge "deep chrome"; stipe 1–3 cm.  $\times$  0.5–0.7 mm., concolorous with the pileus or paler yellow, evenly covered by a faint yellowish pruinose-pubescence, inserted on needles by a yellow strigose base; spores  $7-8 \times 2.5-3 \mu$  (3186),  $8-10 \times 3.5-4 \mu$  (No. 3018), staining pale yellowish with iodine in chloral hydrate, narrowly ellipsoid, apex acuminate; basidia four-spored in No. 3186 and 3421, two-spored in 3018; cystidia  $35-45 \times 10-12 \mu$ , fusoid-ventricose, smooth, filled with a bright sulfur yellow substance, numerous on the gill edge, scattered on the sides; pileus trama with a thin pellicle over the surface, beneath this a layer of enlarged cells filled with a bright yellow substance, central portion floccose, subhymenium with a few greatly enlarged cells with or without yellow contents.

Gregarious on needles in river bottom land, Hoh River, Washington, Oct. 7 (3018), and under spruce at Lake Tahkenitch, Oregon, Nov. 11 (3421) and Nov. 21, 1935 (3586). In consistency and the bright color of the dried specimens this species resembles *Mycena strobilinoidea* Peck. It is also closely related

to *Mycena acicula* Fries from which it is readily separated by the bright yellow gill edge and the smaller spores. *Mycena aurantiidisca* Murr. is a closely related species with abundant fusoid-ventricose cystidia on the sides and edges of the gills ( $37-44 \times 8-11 \mu$ ), and broadly ellipsoid spores which measure  $7-8 \times 4-5 \mu$ . The species described by Kauffman (9) under the name *Mycena aurantiidisca* Murrill is characterized by the absence of cystidia on the sides of the gills, the narrow lanceolate spores which measure  $6-8 \times 2.5-3 \mu$ , and the glandular hairs over the surface of the pileus and stipe. It is very likely that this species is also characterized by a pale yellow gill-edge since Kauffman describes the sterile cells as having a pale yellow content. Kauffman's fungus differs from *Mycena oregonensis* in the glandular covering of pileus and stipe, in the duller colors of the dried specimens, and the lack of cystidia on the sides of the gills. It is here considered to be an undescribed species and named as follows:

***Mycena siskiyouensis* sp. nov.**

Pileus 3-7 mm. latus, membranaceus, conico-campanulatus, subumbonatus, aurantiacus vel saturate luteus, demum pallide citrinus, striatulus, pubescentia stipiti similis minute glanduloso puberulus; lamellae adnatae, angustae, subdistantes, pallidae; stipes 1.5-3 cm. longus, 0.5 mm. crassus, aurantiacus vel pileo concolor; sporae lanceolatae, leves,  $6-8 \times 2.5-3 \mu$ ; cystidia nulla; cellulae aciei lamellarum  $32-35 \times 7-9 \mu$ , ventricosae, apice obtusae.—Specimen typicum in Herb. Mich. conservatum: legit prope Siskiyou National Forest, Takilma, Oregon, Nov. 30, 1935, C. H. Kauffman.

***Mycena tenax* sp. nov. (FIG. 2: 1 and FIG. 3: 4-5).**

Pileus 1-3 cm. latus, ovoide vel convexus, demum obtuse conicus vel umbonatus, lubricus vel subviscidus, politus, fuscus demum griseus, striatus, sapore farinaceo-rancidus; pellicula separabilis et tenax; lamellae confertae, angustae, adnatae, pallidae; stipes 5-7.5 cm. longus, 2-5 mm. crassus, fuscus vel pallide griseus, viscidulus; sporae  $6.5-8 \times 3.5-4 \mu$ , anguste ellipsoideae; cystidia  $60-70 \times 8-12 \mu$ , acuminata.—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope La Push, Washington, Oct. 25, 1935, A. H. Smith, n. 3325.

Pileus 1-3 cm. broad, oval to convex at first, in age broadly conic or obtusely umbonate, disk flattened or slightly depressed at maturity, lubricous to subviscid, glabrous, at first "fuscous" to "hair brown" with a pale grayish margin, in age pale watery gray and striate to the abrupt translucent disk, opaque when faded and pale or dark ashy gray, with a thick tenacious separable pellicle;

flesh pliant, tough, pallid; odor and taste strongly rancid farinaceous or somewhat resembling that of raw cucumber, very pronounced; lamellae close, narrow (2–2.5 mm.), adnate or with a slight tooth, white, becoming grayish in age, edge even and pallid to grayish; stipe 5–7.5 cm.  $\times$  2–2.5 mm., concolorous with the pileus, pruinose above, white strigose at the base, equal, hollow, tenacious, subviscid; spores 6.5–8  $\times$  3.5–4  $\mu$ , narrowly ellipsoid, pointed at one end, staining pale bluish gray with iodine in chloral hydrate; basidia four-spored; cystidia scattered on the sides of the lamellae, 60–70  $\times$  8–12  $\mu$ , narrowly fusiform with a sharp acuminate point, some with thickened walls, cystidia on the gill edge clavate and with finger-like prolongations, gelatinizing as in *Mycena vulgaris* Fries; pileus trama with a typical thin subgelatinous pellicle over the surface, below this a pseudoparenchymatous layer of nongelatinous inflated hyphal cells, beneath this a layer of gelatinizing hyphae 75–120  $\mu$  or more thick, the remainder of typical floccose-filamentose tissue.

Densely gregarious under second growth fir, La Push, Washington, Oct. 25, 1935 (3325); under dense pine, Big Creek, Lincoln County, Oregon, Nov. 6 (Zeller and Smith, Zeller 9307); Lake Tahkenitch, Oregon, under spruce, Nov. 10 (3409), Nov. 11 (3433); Siltcoos Lake, Oregon, Nov. 13 (3449 and 3456); Ada Station, Oregon, Nov. 16 (3503); and Trinidad, California, under redwood, Dec. 11, 1935 (3936). This species fruited in great abundance along the Pacific Coast from La Push to Trinidad, California, during the fall of 1935. In the sand dune region around Siltcoos Lake and Lake Tahkenitch literally thousands of the fruit-bodies were found in large patches every where under the conifers. The species is very closely related to *Mycena quiniaultensis* Kauff., Smith (15) which it resembles in color, size, consistency, spore characters and in having similar cystidia on the sides of the gills. It differs in having a gelatinous gill edge, a thick separable pellicle composed of three distinct layers of tissue, a glassy appearance at maturity, and a very disagreeable taste. Cleland (2) has described a species, *M. subvulgaris* which might be close to *M. tenax*, but he does not give any information concerning either the taste or the nature of the pellicle. In addition, he describes the stem of *M. subvulgaris* as being very glutinous and the cap as darker than in *M. vulgaris*.

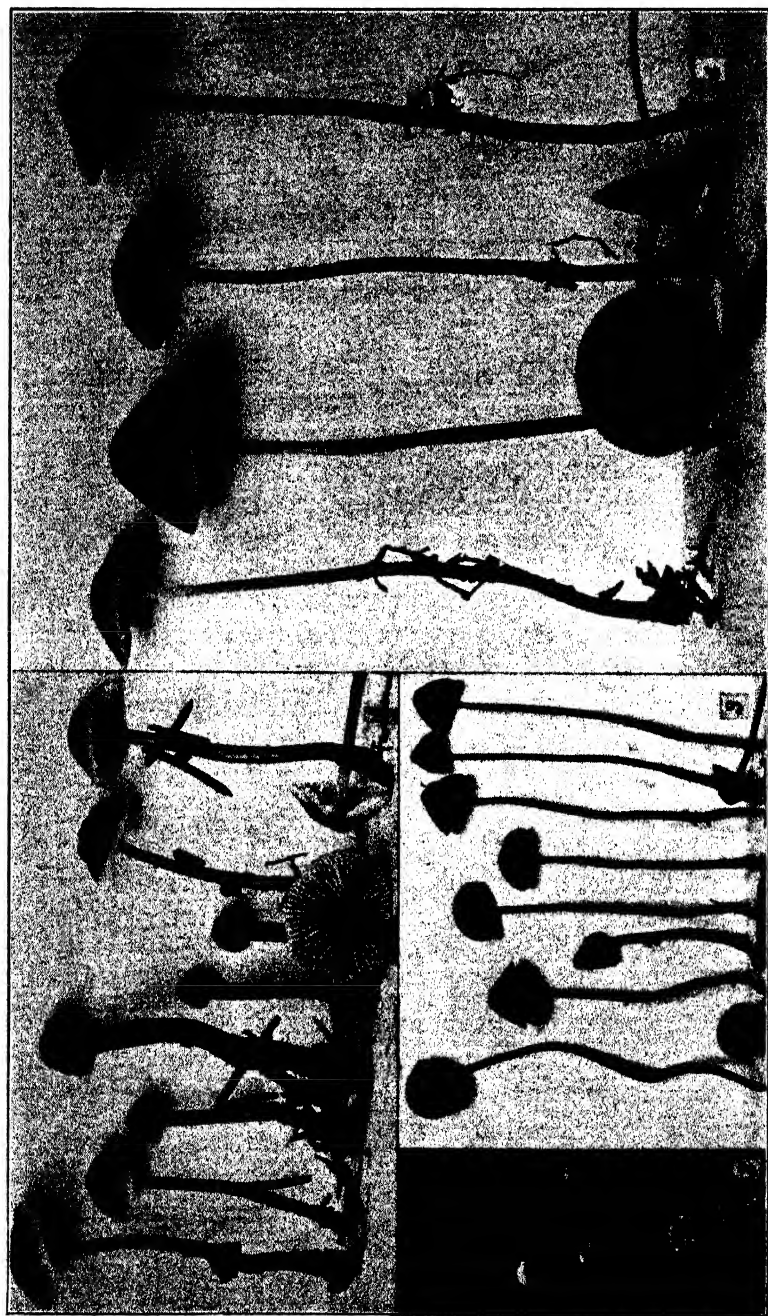


FIG. 2. 1, *Mycena tenax* Smith,  $\times 1$ ; 2, *Mycena juncicola* Fries,  $\times 2$ ; 3, *Mycena amicta* Fries,  $\times 1$ ; 4, *Mycena elegans* Fries  $\times$

## MYCENA ADONIS (Fries ex Bull.) Quél.

Pileus 5-12 mm. broad, conic to campanulate, moist, "scarlet" when fresh, fading to orange or yellowish orange before losing moisture, hygrophanous, "orange buff" when moisture has escaped, margin becoming striatulate at maturity and somewhat wavy in age; flesh thin, fragile, odor or taste not distinctive; lamellae subdistant, narrow, somewhat adnate or attached by a tooth, yellowish or tinged incarnate, margin paler or concolorous with the sides; stipe 2-4 cm.  $\times$  1-2 mm., equal, fragile, at first pruinose, polished in age, pale yellow to white, base often sordid yellow or brownish in age; spores 6-7  $\times$  3  $\mu$ , smooth, hyaline, remaining hyaline when treated with iodine in chloral hydrate; cystidia abundant on sides and edges of the lamellae, hyaline, smooth, fusoid-ventricose, 40-50  $\times$  9-15  $\mu$ ; pileus trama with a thin pellicle over the surface, beneath this a narrow region of slightly enlarged cells, the remainder of floccose tissue.

Gregarious under spruce and fir, Makah Indian Reservation, Washington, Sept. 18 (2490); Lake Ozette, Washington, Sept. 25 (2597); La Push, Washington, Oct. 25 (3332); and Oric, California, Dec. 2, 1935 (3711). The brilliant scarlet colors and abundant cystidia are the most reliable characters. *M. adonis* differs from *Mycena roseipallens* Murr. in the narrower spores, more brilliant and conic pileus, habitat on needle beds, and in its consistently smaller size. When dried carefully, fruit-bodies of *M. adonis* keep their bright colors whereas those of *M. roseipallens* become dull reddish brown.

## MYCENA AMICTA (Fries) Quél., sensu Josseland (7). (FIG. 2: 3.)

Pileus 5-10 (15) mm. broad, obtusely conic, becoming convex with a conic umbo at times, faintly pruinose at first, soon glabrous and lubricous to subviscid, pellicle separable and tenaceous, when young nearly "olivaceous black (1)" on the disk and "light mineral gray" on the margin, often with a strong aeruginous to bluish tint, soon fading to near "wood brown" or "avellaneous" on the disk and near "tilleul buff" on the margin, at times the disk may be tinted vinaceous gray; flesh thin, cartilaginous, odor and taste mild; lamellae close, narrow, narrowly adnate, whitish, becoming pale avellaneous; stipe 4-8 cm.  $\times$  1-1.5 mm., sordid brownish gray, hoary from a dense pruinose-pubescent covering, color beneath a dark greenish blue at first but soon fading to sordid brownish gray, base slightly rooting and covered by bright blue fibrils; spores 7-9  $\times$  4-5  $\mu$ , narrowly ellipsoid, smooth; cystidia

on the gill edge only,  $30-40 \times 4-5 \mu$ , narrowly fusoid and acuminate; pileus trama homogeneous below a thick gelatinous pellicle.

Densely gregarious on needles, Lake Crescent, Washington, Sept. 20 (2515), Sept. 21 (2525), Sept. 24 (2581), and Oct. 22 (3277); Lake Tahkenitch, Oregon, Nov. 21 (3584); Trinidad, California, Nov. 30 (3675) and Dec. 1 (3703); Oric, California, Dec. 3, 1935 (3738). The fungus which Rea (13) has named *Mycena iris* var. *caerulea* was collected sparingly on decaying conifer logs (La Push, Washington, Oct. 25, No. 3330, and along the Mad River, California, Dec. 10, 1935, No. 3917). The more conspicuous pruinosity at the apex of the stipe, the bright blue colors of the pileus, and the larger size are the most striking differences. It apparently is a robust form of *M. amicta*. It seems clear to me, after studying numerous variations of *M. amicta* along the Pacific Coast, and of *Mycena subcaerulea* (Peck) Sacc. in the region of the Great Lakes, that collections of a *Mycena* having bluish or aeruginous tints at first in some portion of the fruiting body, a thick gelatinous pellicle, a rather cartilaginous-flexible consistency, and a densely pruinose stipe can nearly always be properly referred to one of these two species. If the spores are ellipsoid and measure  $7-9 \times 4-5 \mu$ , the species is properly placed in *M. amicta*. If the spores measure  $7-8 \times 6-8 \mu$  and are globose to subglobose, the collection should be placed in *M. subcaerulea*. All measurements should be made on spores from four-spored basidia. The spores of both species turn pale bluish gray with iodine in chloral hydrate.

A study of the type specimens of *Mycena subcaerulea*, *Mycena cyaneobasis* Peck, and *Mycena cyanothrix* Atk. has shown that all are simply forms of one species, properly designated as *Mycena subcaerulea* (Peck) Saccardo. *Mycena caesiialba* Murrill differs from all in this group in having narrowly fusoid cystidia on the sides and edges of the lamellae which measure  $30-49 \times 4-8 \mu$ , and in its spores which are broadly ovoid and measure  $7-9 \times 6-7 \mu$ . The basidia are four-spored.

The writer has collected a minute form of *M. subcaerulea* in New York (Warrensburg, Sept. 14, 1934, No. 905) with a pileus 2-5 mm. broad, and resembling *Mycena corticola* Fries very closely in stature. The pileus was watery gray with conspicuous darker

striations. The base of the stipe was strigose with bright blue hairs. Since the fundamental characters are identical with those of *M. subcaerulea* it is best considered to be merely a form of that species. Similar depauperate forms have been found in other species, *Mycena ulcalina* Fries in particular.

MYCENA AURANTIOMARGINATA (Fries) Quél. (FIG. 1: 5).

Pileus 8-20 mm. broad, obtusely conic to campanulate, becoming nearly plane in age, faintly pruinose, soon polished and lubricous, when moist dark olive fuscous on the disk and the margin bright orange tinged with fuscous or the disk "orange-citrine" to "medal bronze" and the margin "cadmium orange," striate, not hygrophanous, fading to pallid olive brown with an orange tinge or near "naples yellow," somewhat plicate in age; flesh thin, rather pliant, odor and taste not distinctive; lamellae narrow, becoming broad in age, close, bluntly adnate or with a decurrent tooth, pallid to grayish olive on the sides, edges bright "cadmium orange"; stipe 3-6 cm.  $\times$  1.5-2 mm. rigid and cartilaginous, "buffy brown" to "medal bronze" with an orange tinge, glabrous, orange pruinose above, base densely strigose with "cadmium orange" hairs; spores 7-9  $\times$  4-5  $\mu$ , ellipsoid, smooth, staining faintly bluish gray with iodine in chloral hydrate; cystidia abundant on the sides and edges of the lamellae, 28-36  $\times$  7-9  $\mu$ , clavate, the apices sparsely to densely echinulate, filled with a bright orange substance; pileus trama with a thin pellicle over the surface on which are found scattered cystidia similar to those on the gills, beneath this is a region of enlarged cells, the remainder is filamentose and homogeneous.

Widely scattered to gregarious under spruce and fir, Lake Ozette, Washington, Sept. 25 (2595); Lake Crescent, Oct. 10 (3080); Joyce, Oct. 11 (3107); Lake Crescent, Oct. 22 (3283); Joyce, Washington, Oct. 28 (3393); Lake Tahkenitch, Oregon, Nov. 11 (3435); Siltcoos Lake, Oregon, Nov. 13, 1935 (3455). One collection was obtained at Trinidad, California, Dec. 2, 1935 (3725). During the early part of the season only a few scattered fruiting bodies were found at a time on the needles under fir and hemlock. Later, particularly in the second growth fir around Joyce, Washington, it grew in dense troops. This is clearly the species described and illustrated by Konrad & Maublanc (11). As they have pointed out, the color of the pileus varies greatly, but the species can always be recognized by the bright orange



edging of the lamellae. The color of the gill edge is very comparable to that of bright orange pilei of *Mycena leajana* Berk., and fades but little even in extreme age.

*MYCENA ELEGANS* (Fries ex Pers.) Quél. (FIG. 2: 4).

Pileus (4-10) 15-25 (35) mm. broad, convex to obtusely conic, becoming broadly campanulate to subumbonate in age, moist, at first densely white pruinose, soon polished, subhygrophanous, "dark olive" when fresh, margin "light chalchledony yellow" fading to a sordid olive gray with a whitish margin before losing moisture, pale "avellaneous" to pale olive gray when faded, striate to the disk when moist, margin entire; flesh watery gray, fragile, odor and taste not distinctive; lamellae narrow, moderately close to subdistant, ascending adnate, dull pale olive gray, margin "pale green yellow," at times staining sordid purplish brown in age; stipe 4-9 cm.  $\times$  1-2 mm. or 10-12 cm.  $\times$  2-3 mm. equal or base slightly enlarged, base densely strigose with "pale green yellow" hairs, faintly pruinose above, polished in age, pale or dark olive gray with a decided yellow tinge, apex at times pale yellow, tubular, fragile, in age tending to become dull reddish brown; spores  $7.5-9 \times 4-4.5 \mu$ , ellipsoid, smooth, staining pale bluish gray with iodine in chloral hydrate; cystidia on sides and edges of the lamellae,  $28-33 \times 7-10 \mu$ , clavate, with echinulate apices; pileus trama with a thin adnate subgelatinous pellicle, below this a region of inflated cells irregularly arranged, the remainder of floccose filamentose tissue.

Scattered to gregarious under cedar at Siltcoos Lake and Lake Tahkenitch, Oregon, Nov. 13-19, 1935 (3453, 3508, 3546), and under redwoods in Praire Creek State Park, Oric, California, Dec. 2-4, 1935 (3714, 3709, 3757). Konrad (10) and other investigators in Europe have referred *M. elegans* to *M. aurantiomarginata* as a synonym. As pointed out above, my collections of *M. aurantiomarginata* compare well with the description of that species by Konrad and Maublanc (11). It is obvious, however, that their description does not apply to the larger, darker species with the pale yellow colors on the gill edges and stipe. Fries (4 and 5) described the gill edge of *M. aurantiomarginata* as "aurantia" and "aurantiis" whereas the edge of the gills in *M. elegans* is described as "crocea" and "croceis." Wharton (17) in discussing Fries' nomenclature of colors includes the term croceus or saffron yellow in the group of pale yellows such as sulphur

yellow, straw color, etc. and aurantius is classed with the orange yellows and described as being a full orange, cadmium orange. Using this interpretation of the Friesian color terms, the American collections described above fall readily into two groups which are very easily recognized and which have not been observed to intergrade. It thus seems advisable to recognize both as distinct species. Their cystidia are alike, but they differ in consistency. *M. aurantiomarginata* is not as fragile as *M. elegans*. As shown in the photographs, there is considerable difference in stature but this must be used with caution. The dark olive-black ground color of *M. elegans* reminds one somewhat of *M. alcalina* Fries whereas that of *M. aurantiomarginata* is bronze tinged with gray. In addition, in wet weather the flesh of *M. elegans* has a rather pronounced tendency to stain reddish brown in both the cap and stipe.

The writer (16) recently described under the name *Mycena elegans* (Pers.) Quél. a fungus commonly found on oak leaves and humus in the vicinity of Ann Arbor, Mich. This differs from the typical form in the densely white strigose base of the stipe, the fuscous disk and pale grayish margin of the pileus, and pallid gills which sometimes lack the yellow edging. It grades imperceptibly into the species and should be considered only as an ecological form.

#### MYCENA CAPILLARIPES Peck (FIG. 1: 2).

Since publishing an account (15) of this species, it was collected abundantly in the Adirondack Mts. of New York (691, 701, 713, 724, 834) during the fall of 1934. During the same season Prof. E. B. Mains collected it at Marquette and Little Lake, Michigan (E.B.M. 34-166, 34-191, 34-194). During the season of 1935 it was found scattered on mossy slopes in oak-hickory groves near Ann Arbor (1345, 1418, 1649), in dense troops covering large areas in a spruce plantation (1369, 1616, 1741, 1742) at Ann Arbor, and fairly abundant under Douglas Fir in the vicinity of Lake Crescent, Washington (2532, 2509, 2548, 2743). The Ann Arbor collections have all been characterized by two-spored basidia or a variable number, two-, three-, and four-spored all on the same pileus. The spores of the two-spored form usually measure  $10-12.5 \times 5-6.5 \mu$ , but often larger spores (11-14

$\times 6-8 \mu$ ) are found. The collections from the Adirondacks, northern Michigan and Washington were all four-spored; the spores from deposits measuring  $8-10 \times 4-5 \mu$  or  $7-9 \times 3-4 \mu$  in the Adirondack specimens. Two distinct color forms were present in the collections from the spruce plantation (1741, 1742). In No. 1741 the pilei were "light seal brown" or "seal brown" on the disk with a "vinaceous-brown" margin. In some the disk was "dark livid brown" to nearly "fuscous." In age the colors faded to "cinnamon drab" or sordid grayish brown. In no. 1742 the colors were "Prussian red" to "dark indian red" becoming "vinaceous-fawn" at maturity or gray with a faint vinaceous tinge. The basidia of both were bispored. Each form was always found in a definite localized area. The odor which is one of the striking characters of this small fungus, was very weak to almost lacking in the Washington material. Here again, all other characters placed the fungus in this species. The spores of all of the collections stain faintly bluish gray with iodine in chloral hydrate.

MYCENA CINERELLA Karst. (FIG. 1: 1).

Pileus (3)5-10 mm. broad, obtusely conic, striate to apex, dark gray over the disk and striae, remainder paler, margin whitish, surface glabrous and lubricous, margin entire, appressed against the stem at first; flesh thin, cartilaginous and tough, odor and taste rancid and disagreeable; lamellae moderately close to subdistant, moderately broad, broadly adnate-decurrent, pale gray, edge whitish; stipe (2.5)3-5 cm.  $\times$  0.7-1.5 mm. equal, base slightly enlarged and only slightly strigose, pallid gray or whitish, always pallid above, faintly pruinose, cartilaginous; spores  $6.5-8 \times 3.5-4 \mu$ , pointed at one end, staining faintly yellowish with iodine in chloral hydrate; basidia four-spored; cystidia on edge only, clavate, the apex set with minute rod-like projections,  $24-28 \times 5-8 \mu$ , pileus trama with a thin pellicle over the surface and a region of inflated cells beneath it, the remainder of floccose-filamentose tissue.

Gregarious on needles under pine, Marquette, Michigan, Sept. 12, 1934 (E. B. Mains 34-174); under bishop pine, Trinidad, California, Dec. 10, 1935 (3918). This is apparently the first report of typical material of the species from North America. It may have been found previously and placed in the genus

*Omphalia* where it would be near *O. picta* Fries. The Michigan and California collections are similar to material received from England.

*MYCENA EXCISA* (Fries ex Lasch) Gill.

Pileus 2–3.5 cm. broad, broadly conic to nearly plane, dry, densely white pruinose at first, soon polished, "fuscous" or darker on the disk, margin paler and tinged with brown, fading to fuscous gray in age, margin opaque when moist, radially rugulose at maturity and entire; flesh thin, tough and cartilaginous, grayish brown, odor and taste none; lamellae broadly and deeply adnexed, ventricose and broad, subdistant to close, white, becoming faintly fuscous or grayish, edge white or grayish; stipe 3–4.5 cm.  $\times$  2–3 mm., short and cartilaginous, tough, pale fuscous below, pallid above, evenly white pruinose at first, polished in age, often compressed and twisted; spores 8–10 (12)  $\times$  6–6.5  $\mu$ , broadly ellipsoid, smooth, staining faintly bluish gray with iodine in chloral hydrate; cystidia abundant to scattered on the sides of the gills, 50–65  $\times$  10–12  $\mu$ , fusoid-ventricose, those on the gill edge 30–45  $\times$  10–12  $\mu$ , fusoid ventricose or with apices branched; basidia four-spored; pileus trama with a thin adnate pellicle over the surface, a region of inflated cells beneath it and the remainder of floccose-filamentose tissue.

Gregarious on humus in mixed woods, Crescent Beach, Washington, Sept. 22, 1935 (2544); and scattered to subcespitose on very decayed conifer logs, Crescent Beach, Sept. 24 (2574) and Oct. 12 (3113). The cystidia, the broad and deeply adnexed gills, the short stipe, and the tough cartilaginous consistency characterize the species.

*MYCENA FILIPES* (Fries ex Bull.) Quél.

Pileus (5) 10–20 (25) mm. broad, obtusely conic, campanulate, or with a flaring margin and a long obtuse umbo, the buttons cylindric to oval, at first with a faint bloom, glabrous, umbo "fuscous" at first, fading to "benzo brown" margin watery gray or paler, gradually fading to whitish gray with a pale brownish gray disk, striate when moist, sulcate at times in age, margin entire; flesh thin, taste mild, odor none, rather fragile; lamellae close to scarcely subdistant, narrow, adnate, pallid brownish drab or a darker gray, edge whitish, projecting to the edge of the pileus; stipe (5) 8–12 (15) cm.  $\times$  1–2 mm. pale fuscous, the apex often bluish black at first, fading to pallid gray or pallid watery white

above, becoming grayish and finally dark brownish drab below, hoary, translucent in age, equal, straight or twisted, very brittle, base rooting slightly and white strigose; spores  $7-9 \times 4-5 \mu$ , narrowly ellipsoid, staining pale bluish gray with iodine in chloral hydrate, smooth; basidia four-spored; cystidia  $35-44 \times 12-22 \mu$ , echinulate, with a large globose head and a narrow pedicel, rare on the sides, forming a broad sterile band on the edge.

Gregarious under pine, Florence, Oregon, Nov. 14 (3473) and Nov. 20, 1935 (3563). This species was collected in great abundance and ample opportunity was found to study its variations. *Mycena iodiolens* Lundell and *M. atroalboides* Peck are its nearest relatives. *M. iodiolens* can be readily distinguished by the rather distinct sterile margin of the pileus which tends to become somewhat frayed at times as well as by the pronounced odor of iodoform which develops after the fruiting bodies are collected. In all of my collections of *M. filipes* the gills project to the edge of the pileus and are broader as well as more distant than those of *M. iodiolens*. *Mycena atroalboides* differs in the more expanded pileus with a characteristically flattened umbo, in its tendency to stain reddish brown where bruised or broken, and in its short stem when not growing in deep moss such as sphagnum. House (6) has published a description and illustration of the two spored form of *M. filipes* based on Atkinson's material. Beardslee (1) states that it is common in North Carolina and Ohio, but the writer has rarely collected it in Michigan.

#### MYCENA GALOPODA (Fries ex Pers.) Quél.

Pileus 5-25 mm. broad, conic to conic-campanulate, at first with a hoary sheen, "fuscous-black" on the disk at maturity, remainder abruptly paler and usually watery gray to whitish, striate to disk when moist, margin entire; flesh thin, soft, fragile, no distinctive odor or taste; lamellae subdistant, narrow, adnate, whitish or gray, usually darker in age, edge whitish or gray; stipe 4-8 (11) cm.  $\times$  1-2 mm., dark blackish brown below, paler at the apex, fragile, glabrous except for the white strigose base, exuding a white milk-like juice when broken; spores 9-12 (13)  $\times$  5-6  $\mu$ , smooth, staining yellowish with iodine in chloral hydrate; basidia four-spored; cystidia abundant on the sides of the gills,  $70-90 \times 10-14 \mu$ , fusoid-ventricose or the tip sharply acuminate, those on the gill edge shorter and often forking at the apex; pileus trama with a thin pellicle over the surface and a region of

inflated cells irregularly arranged beneath it, the remainder homogeneous.

Gregarious on needles and debris under Douglas Fir, spruce and redwood, Boulder Creek, Olympic Hot Springs, Washington, Oct. 15 (3151); Sol Duc Hot Springs, Washington, Oct. 17 (3209); Lake Crescent, Washington, Oct. 18 (3215); La Push, Washington, Oct. 23 (3335); Siltcoos Lake, Oregon, Nov. 13 (3454); Florence, Oregon, Nov. 14 (3471); Trinidad, California, Nov. 30 (3668) and Nov. 30 (3677); Oric, California, Dec. 2 (3724) and Dec. 3, 1935 (3737). In California this species fruited abundantly around the bases of old redwood stumps as well as on the debris at the bases of living trees. In robust fruiting bodies such as those usually found around the redwoods, the milky juice was copiously exuded from any injured portion, but in smaller individuals it could frequently be demonstrated only at the base of the stipe. Beardslee (1) reports the species as common during the summer around Ashville, North Carolina.

*MYCENA JUNCICOLA* (Fries) Gill. (FIG. 1: 4 AND FIG. 2: 2).

Pileus 1–3 mm. broad, conic to convex or broadly convex, at times with a slight papilla, usually uneven or rugulose around the disk, glabrous, moist and shining, flesh opaque, sulcate striate to the disk in fresh specimens, disk tinged purplish to vinaceous or grayish vinaceous, margin paler and whitish; flesh membranous, fragile, odor and taste not distinctive; lamellae distant, broadly adnate, narrow or moderately broad in large caps, pale grayish vinaceous, edge whitish to gray; stipe 3–5 (10) mm. long, filiform, glabrous above, hyaline, grayish white or grayish vinaceous, attached to the substratum by a flat vinaceous brown plate  $\frac{1}{2}$  to 1 mm. broad; spores  $9\text{--}11 \times 5\text{--}6 \mu$ , staining pale yellowish with iodine in chloral hydrate basidia four-spored; cystidia numerous on the gill edge,  $28\text{--}34 \times 7\text{--}10 \mu$ , clavate with echinulate apices, not present or very rare on the sides.

Densely gregarious to subcespitose on sedge culms, at the bases of the clumps on the sheaths or on old exposed roots, Lake Tahkenitch, Oregon, Nov. 17, 1935 (3512), Nov. 18 (3545) and Nov. 24 (3613). This species is most closely related to *Mycena pterigena* Fries which it resembles in consistency, stature, broad distant gills, cystidia and spores. It is easily distinguished by the duller reddish vinaceous colors, the pallid gill edge, the

characteristic flat plate at the base of the stipe, and the shorter grayish vinaceous stem. The stipe separates from the pileus fairly easily in mature individuals and in all probability the species should be classed in the group *Insiticia* as defined by Kühner (12). Free hand sections however do not show a sharply distinct zone of narrow hyphae at the apex of the stem.

#### MYCENA MILITARIS Karst.

Pileus 3–4 mm. broad, conic-campanulate, in age with a sharply conic umbo, small forms often papillate, glabrous, viscid, "fus-cous" to blackish on the disk, "hair brown," "wood brown," "avellaneous," or pale gray on the margin, pellucid striate when moist, sulcate at maturity, in age pallid cinereous with a blackish umbo; lamellae gray, subdistant, bluntly adnate or with a small decurrent tooth, moderately broad, edge whitish; stipe 2.5–3 cm.  $\times$  1 mm. yellowish gray below, paler above, pallid over all and somewhat translucent in age, very viscid, base bulbous; odor and taste faintly farinaceous; spores 8–10  $\times$  3–3.5  $\mu$ , staining bluish gray with iodine in chloral hydrate; basidia four-spored; pileus trama divided into two regions by a zone of cells with dark brown contents, upper half gelatinous, lower portion filamentose; the stipe with a thick gelatinous sheath.

Gregarious under conifers, Wagner's Falls, Munising, Michigan, Sept. 7, 1933 (33–896) and Warrensburg, New York, Sept. 4, 1934 (903). The collections described above contain smaller fruiting bodies than those originally described by Karsten. A difference in size alone however is not important. The conic to campanulate pileus, the spores, and the bulbous base of the stipe, as Karsten pointed out, separate the species from *Mycena vulgaris*, its nearest relative. The spores of *M. vulgaris* usually measure 6–8  $\times$  4–5  $\mu$ . No reddish spots were noticed in either of the writer's collections but since both were made during comparatively dry weather it does not seem advisable to place much emphasis upon their absence.

#### MYCENA SCABRIPES Murrill (FIG. 3: 6, 7).

Pileus 1.5–3.5 (5) cm. broad, evenly conic, convex, becoming plane with a small conic umbo, pruinose at first, soon polished, "mummy brown" to "clove brown" on the disk, "olive-brown" to "buffy brown" on the striatulate margin, hygrophanous, fading to near "drab" disk remaining darker, surface often rugulose

around the disk, margin appressed against the stipe at first; flesh thick on the disk, thin toward the margin, dark brownish gray, rather firm, odor and taste not distinctive; lamellae adnate to broadly adnexed, seceding readily and at times adhering to each other forming a collar around the stipe, broad, subdistant to distant, pallid to grayish, edge pale or grayish, pruinose under a lens; stipe 4-10 cm.  $\times$  2.5-5 mm., equal, hollow, fragile, at first densely pruinose, in age subsquamulose, glabrescent and silky

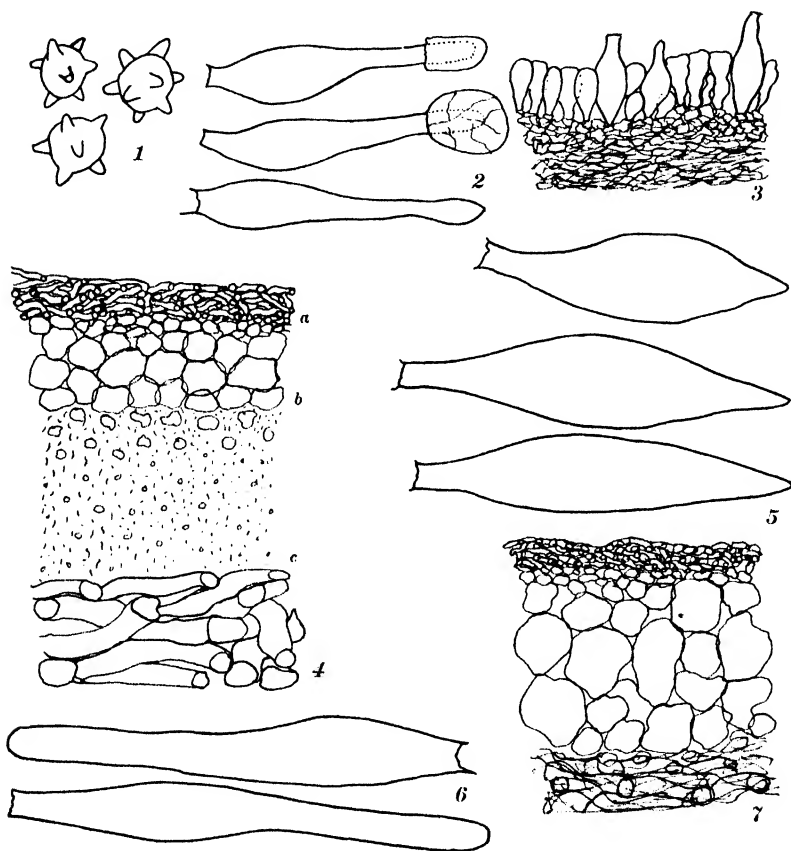


FIG. 3. 1-3, *Mycena nodulosa* Smith: 1, spores,  $\times$  1100; 2, cystidia from the sides of the gills,  $\times$  620; 3, tangential section showing the cellular structure of the surface of the pileus,  $\times$  450. 4-5, *Mycena tenax* Smith: 4, tangential section through the pileus showing a, the pellicle, b, the pseudo-parenchymatous layer, c, the gelatinous layer above the filamentose trama,  $\times$  275; 5, cystidia from the sides of the gills,  $\times$  750. 6-7, *Mycena scabripes* Murrill: 6, cystidia from the sides of the gills,  $\times$  750; 7, tangential section of pileus showing the region of inflated cells beneath the pellicle,  $\times$  275.



striate at times, pale olivaceous brown or grayish, apex pallid; spores 7-9 (10)  $\times$  5-6  $\mu$ , broadly ellipsoid, staining faintly bluish with iodine in chloral hydrate; basidia four-spored; cystidia very abundant on the sides and edges of the gills, 60-100  $\times$  8-14  $\mu$ , smooth, with an inflated base and a long narrow neck, apex obtuse; pileus trama with a thin pellicle over the surface from which project occasional cystidia, beneath this a region of enlarged cells, the remainder of loose floccose filamentose tissue.

Gregarious on humus in oak groves near Ann Arbor, Oct. 5 (32-515), Oct. 15 (32-548) and Oct. 20, 1932 (32-647). Singly to gregarious on exposed soil and along trails under redwoods, Oric, California, Dec. 3 (3736), Dec. 4 (3752) and Dec. 5, 1935 (3785 and 3812). The spores of the type measure 8.5-11  $\times$  6-7  $\mu$ , and the basidia are two-spored. Cystidia are scattered on the sides and edges of the lamellae, are cylindric to subfusoid, smooth, apices obtuse, and measure 77-95  $\times$  8-10  $\mu$ . The colors of fresh pilei are darker than those given by Murrill, but the densely pruinose to scabrous stipe, the long cystidia and broad, subdistant gills amply characterize the species. Large fruiting bodies might be mistaken for a species of *Tricholoma*, but the stipe is very fragile. Both this species and *Mycena atribrunnea* Murrill should be carefully compared with *Collybia floccipes* Fries. During the spring of 1935 *M. atribrunnea* was collected very abundantly in the vicinity of Ann Arbor. The stem is at first scurfy from a dense coating of fine particles the tips of which are tinged gray or brownish. This coating is easily removed and then the stem is pure white. Kauffman's (8) specimens of *Collybia floccipes* are similar to those Murrill described as *Mycena atribrunnea*. The stipe of *Mycena scabripes* also indicates a close relationship to *C. floccipes*, and Cook's (3) illustration which Rea (14) cites could easily be either a large form of *M. atribrunnea* or a small *M. scabripes*. Because the pileus structure in both of Murrill's species resembles more closely that of *Mycena* than that of *Collybia*, it seems best to retain them in the former genus.

#### MYCENA TENELLA (Fries ex Schum.) Quél.

Pileus 3-10 mm. broad, obtusely conic, remaining so in age, glabrous, moist, striate at first, somewhat sulcate in age, "light pinkish cinnamon" to "vinaceous-buff" fading to nearly white with a faint rosy tint or the disk finally creamy yellowish; flesh

thin but cartilaginous and firm; lamellae narrow, close to subdistant, adnate, white or tinged with rose, edge at very first tinged with rose but soon white or concolorous with the sides; stipe 6-10 cm.  $\times$  1 mm. glabrous, dark drab gray with a paler apex, rather firm and elastic; spores 8-10  $\times$  5-6  $\mu$ , smooth, hyaline, staining faintly bluish gray with iodine in chloral hydrate; cystidia abundant on edge and rare or scattered on the sides of the lamellae, the apices echinulate; basidia four-spored.

Cespitose to densely gregarious on dead clumps of fern roots in low land, Joyce, Washington, Oct. 3, 1935 (2834). This species is close to *Mycena mirata* Peck from which it differs in its lighter more rosy color and cespitose habit. The stems in the above collection were longer than usual.

#### MYCENA TRACHYSPORA Rea (FIG. 1: 6).

Pileus (6) 10-20 (30) mm. broad, conic, campanulate, becoming expanded and umbonate, at first densely hoary, polished at maturity, surface dry, disk at first dark "fuscous" or "bone brown," paler and grayish toward the margin, in age paler over all and often with a tinge of sordid ochre, somewhat striate at first; flesh firm and cartilaginous, odor and taste not distinctive; lamellae moderately close, narrow to moderately broad, oval in outline, narrowly adnate, pale grayish with a pallid margin, densely pruinose under a lens; stipe 4-12 cm.  $\times$  1-2 mm., equal, tough and cartilaginous, pallid gray above, darker and more brownish below, evenly covered by a dense layer of cystidia, appearing pubescent under a lens; spores 4-5.5 (6.5)  $\mu$ , pale yellowish with iodine in chloral hydrate; basidia four-spored; cystidia abundant on sides and edges of the gills, 40-75  $\times$  8-12  $\mu$ , fusoid-ventricose or with a long projecting shaft with an obtuse apex, smooth or rarely with the lower portion of the shaft incrustated; pileus trama homogeneous, covered by a thin pellicle from which occasional cystidia arise.

This species approaches *Mycena Cooliana* Oort very closely, but the gills were neither thickish nor subdistant, and incrustated cystidia were rarely found. When present, the incrustation is not over the apex but at the base of the neck. Fruiting bodies with stems 12 cm. long and pilei 3 cm. broad resemble *M. nodulosa* in general appearance but are easily distinguished by the lack of a long pseudorhiza and the thin pellicle of the pileus. Mr. H. E. Parks and the writer collected this species fairly abundantly under

pure stands of redwood in northern California, Dec. 2-3, 1935 (3718) and (3731).

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# CYTOLOGY OF SPORE GERMINATION IN THE BISPORED FORM OF *PSALLIOTA CAMPESTRIS*

J. E. SASS

(WITH 1 FIGURE)

The nuclear phenomena in the mycelium and hymenium of the bisporoid form of *Psalliota campestris* have been studied by several investigators, who are in substantial agreement with respect to most of the nuclear cycle. One point of controversy concerns the number of nuclei which enter each spore. Buhr (1) states that only one of the four nuclei in the basidium enters each of the two spores, whereas Miss Colson (2) and the present writer (3) agree that two nuclei enter each spore.

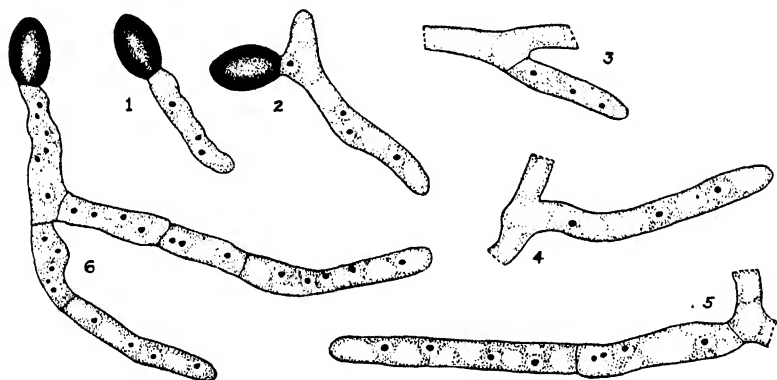


FIG. 1. Nuclear features of germ tubes of the bisporoid forms of *Psalliota campestris*.

A commercial culture which is grown here was found to have the same nuclear features as the material previously studied by the writer, further supporting Miss Colson's account. Spores of the present strain germinated readily, making possible a study of this little-understood phase of the nuclear cycle.

As illustrated in figure 1, the young, unseptate germ tube is multinucleate. Septation occurs with the growth and branching of the mycelium, the cells of which are multinucleate. This condition is a constant feature of the mycelium, whether derived

from single spores, mass smears of spores, or tissue cultures of the fruit body.

These nuclear conditions eliminate the use of nuclear criteria of heterothallism or homothallism and makes necessary the continuation of culture experiments, using giant cultures, rather than the flats of compost used heretofore in such tests.

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# A NEW SPECIES OF CHONDROPODIUM ON PSEUDOTSUGA TAXIFOLIA

W. LAWRENCE WHITE<sup>1</sup>

(WITH 7 FIGURES)

The sphaeropsidaceous fungus, here discussed, was first encountered by Doctor J. S. Boyce of Yale University near Bear Springs, Clackamas County, Oregon, August 23, 1930. Two additional collections were made by J. R. Hansbrough near Revelstoke, British Columbia and Madras, Oregon in August of 1930 and 1931 respectively. The organism was found in small sunken lesions in the outer cortex of smooth-barked trees of *Pseudotsuga taxifolia*. It is stated by the collectors to be common but not serious from the disease standpoint.

Impressed by the superficial resemblance of the fruit-bodies of the fungus to those of *Caliciopsis*, Doctor Boyce sent material of the three collections to Professor Fitzpatrick. Careful search of the literature having failed to reveal any record of the occurrence of such a form on *Pseudotsuga* or any closely related host, the writer, at Professor Fitzpatrick's suggestion, undertook the study which has resulted in the preparation of this paper.

The lesions occupied by the fungus are small, superficial, slightly sunken, and often somewhat orbicular in shape, being then slightly greater in lateral than in vertical diameter (FIG. 3). They measure  $1-2 \times 1-1.5$  cm. The outer cortex has a tendency to crack along the margin of the cankered area and to pull away from the adjacent healthy tissue, leaving the canker sharply defined. From two to a dozen erumpent (FIG. 3) pycnidia occur, scattered over the central area of each canker. The pycnidium is an erect columnar body, chiefly cylindrical, but sometimes spreading at the base, and typically compressed apically when dry (FIG. 2). It measures 1-1.5 mm. in height and  $125-200 \mu$  in thickness. The spreading base, more or less covered by the

<sup>1</sup> The writer wishes to acknowledge his indebtedness to Doctor H. M. Fitzpatrick for valuable suggestions and for a critical reading of this paper.

thin outer cortical layer of the host, may attain a diameter of 500  $\mu$ . Though the pycnidia usually stand singly, two or three may be found clustered together, their bases sometimes united in a common basal stroma. Externally the pycnidium is black

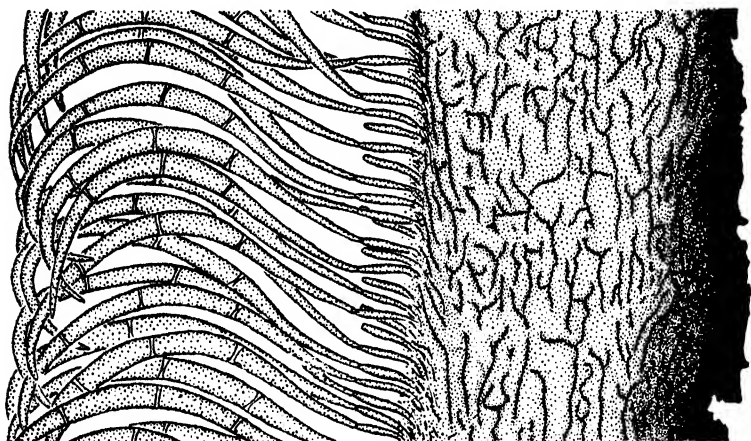


FIG. 1. Lateral wall of pycnidial cavity of *Chondropodium Pseudotsugae* bearing conidiophores and conidia. (Drawn to a magnification of 720 with aid of camera lucida and not reduced in reproduction.)

and minutely scabrous. The pycnidial cavity occupies the apical region of the column (FIG. 5, 6, 7). In wet weather it opens by a broad circular ostiolum freeing its crescent-shaped, 4-celled conidia. When dry it collapses completely, the compressed apex of the column then having the aspect of a coarsely toothed wedge (FIG. 2). The column beneath the locule is composed of a compact, subgelatinous to cartilaginous tissue, formed of closely interwoven hyphae which are chiefly subhyaline but at the periphery are darkened to provide a thin black rind (FIG. 6).

Since the genus *Chondropodium* is not well known, and because of the confused ideas of the limits of related genera, a brief discussion of our reasons for placing the species in this genus will be given.

The organism is excluded from *Sphaerographium* Saccardo because of its septate spores. It is excluded from *Pseudographium* Jaczewski because the description of the latter genus as amended by von Höhnelt (1, no. 921, pp. 67-69) with *P. Persicae* as the type, calls for pycnidia composed of brown

parallel hyphae, and a columnar stalk arising from hyphae superficial on the substratum. Examination of *P. Persicae* shows it to be strikingly different in gross aspect from the fungus with which we are dealing here.

The genus *Corniculariella* Karsten (3: 57), based on *C. Abietis* Karst., was characterized by him as having erect, superficial, caespitose, or rarely single pycnidia, and septate, hyaline or yellowish pycnospores. In 1890, apparently without reason and without giving any explanation he (4: 19) changed the name of the genus to *Cornularia*. By 1916 eleven additional species had been placed in the genus. At that time von Höhnelt (2, no. 958, 19–21) showed that all except three of these belong to other genera, these three—*C. spina* (Berk. & Rav.) Sacc. & Sydow, *C. Viburni* Sacc. and *C. Urceolus* v. Höhn.—being regarded by him as closely related species which might well be retained and treated as a genus. Meanwhile, *C. Abietis*, on which the genus *Corniculariella* had been based, apparently had not been collected again and was known only from the inadequate original description. This led von Höhnelt (2, no. 956, p. 42, no. 958, p. 45) to suggest that Karsten's description might have been based on a specimen of *Gelatinosporium Pinastri* (Moug.) v. Höhn. Knowing *C. Abietis* only from Karsten's description he made it synonymous with *Gelatinosporium Pinastri*, thus making *Cornularia* a synonym of *Gelatinosporium* Peck, and erected, for the three species named above, a new genus, which he named *Chondropodium*, it being his opinion that *Cornularia* should remain monotypic at least until the type species should become better known. Finally he placed in *Chondropodium* the species *Sphaerographium hystricinum* (Ellis) Sacc., stating on meagre evidence that in its perfect stage it also belongs to the genus *Godronia*.

A close relationship of *Chondropodium* to *Gelatinosporium* is indicated by von Höhnelt, and perhaps not essentially different is the genus *Micropera*.

Though the original description of *Cornularia* states that the pycnidia are superficial, the species placed in *Chondropodium* as well as *Gelatinosporium Pinastri* have actually erumpent pycnidia. It seems likely, therefore, that the terms "erumpent" and "superficial" were used somewhat vaguely by these authors.



Von Höhnelt did not present a formal diagnosis of his new genus, *Chondropodium*. He wrote as follows concerning the species on which it was established:

"Diese Pilze haben ein eingewachsenes schwarzes Hypostroma, auf dem, meist büschelig verwachsen, mehrere aufrechte, meist sehr unregelmässig gestaltete, aussen schwarze, innen blasse, gelatinös-knorpelige Stromata sich erheben, die aus plectenchmatisch verflochtenen, knorpelig-dickwandigen Hyphen bestehen, oben meist konisch verschmälert sind und daselbst einen aufrecht-elliptischen oder zylindrischen Lokulus zeigen, in dem sich auf einfachen Trägern spindelig-zylindrische, lange, hyaline, einzellige oder undeutlich zweibis mehr-zellige Conidien finden. Lokulus schliesslich sich oben klein, rundlich öffnend."

This description applies extremely well to our fungus on *Pseudotsuga taxifolia*. In the erumpent character of the pycnidium, the gelatinous-cartilaginous nature of its tissue, the form and method of dehiscence of its locule, and in the shape and septation of its conidia there is complete agreement. Whether in its perfect stage it is a *Godronia* is not known.

In erecting the genus *Chondropodium* it is clear that von Höhnelt has attempted to bring together related species. Students who regard the classification of the Fungi Imperfecti as merely a cataloging system based on artificial characters may raise objection to the recognition of this genus on the ground that it represents unnecessary splitting of the older more inclusive genus *Cornularia*. While it will be admitted that classification in the group as a whole must of necessity rest on artificial bases, there seems to be no sound objection to placing subdivisions of the group on a natural phylogenetic basis where possible. For this reason we prefer to place the organism under discussion in *Chondropodium* rather than in the larger and admittedly artificial genus *Cornularia*.

### ***Chondropodium Pseudotsugae* sp. nov.**

Pycnidii plerumque singulis, rarius vel binis vel quaternis, erumpentibus, stipatis, columnaribus, erectis, 1-1.5 mm. altis, in superiori parte cylindraceis 125-200  $\mu$  diam.; basi interdum ad 300-500  $\mu$  incrassante partimque summo cortice immersa; extrinsecus atris, minuteque scabris, duris ac fragilibus si sicca; ostiolo largo, circulari, compresso et occluso si siccum; loculis sporiferis, per totam interiorem faciem conidiophoris vestitis, elongatis, 1/4-1/3 superioris

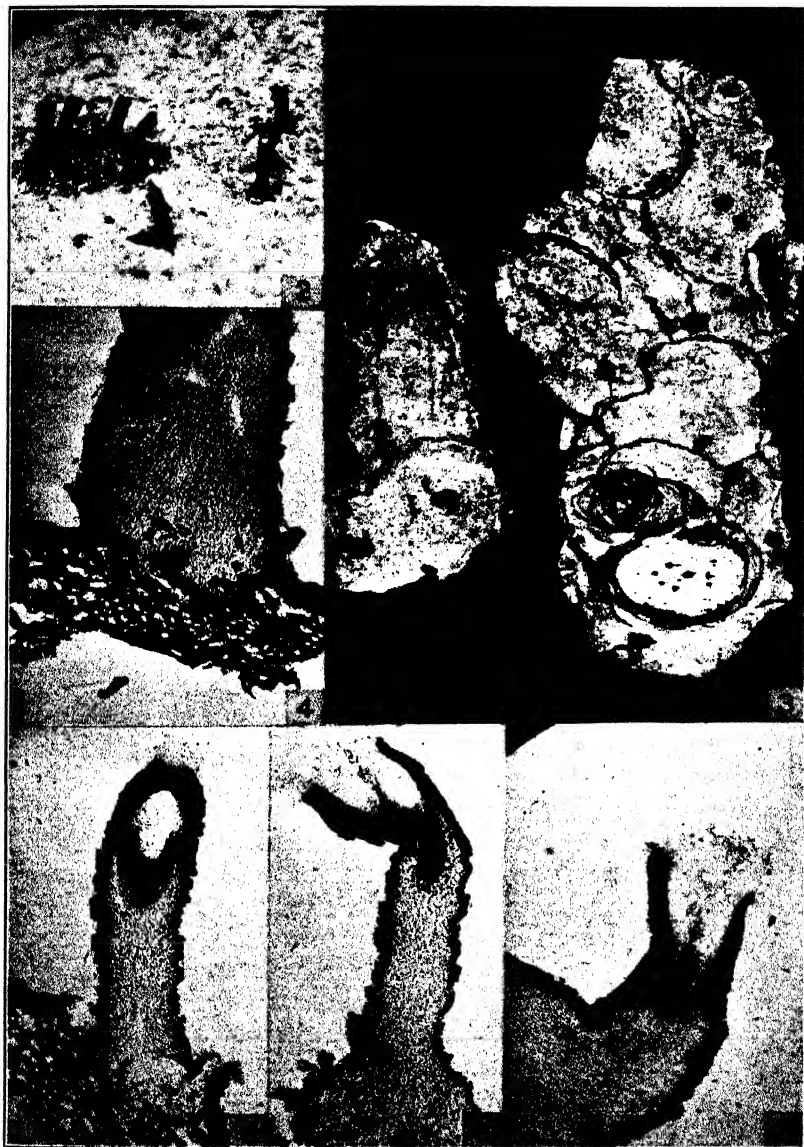


FIG. 2-7. Photographs of *Chondropodium Pseudotsugae*: 2, erumpent pycnidia in canker,  $\times 3.8$ ; 3, characteristically sharply delimited cankers on *Pseudotsuga taxifolia*,  $\times 1.4$ ; 4, longitudinal section through erumpent basal portion of pycnidium,  $\times 28$ ; 5, longitudinal section through pycnidium, not median at apex but indicating position and width of ostiolum through which extruding spores are shown,  $\times 28$ ; 6, 7, pycnidium in longitudinal section, the locule apparently widely dehiscent due to spreading of walls following sectioning,  $\times 28$ .

columnae partem obtinentibus; basi sterili, ex hyphis facta septatis, dense intectis, ramosis, quae agglutinatae texturam reddunt subgelatinosam oel etiam cartilaginosam, fuscis circum fructus superficiem, tenuem et atram crustulam efficientibus; conidiophoris simplicibus, aseptatis,  $12-16 \times 2-2.5 \mu$ ; conidiis hyalinis,  $35-60 \times 3.5-4.5 \mu$ , si libera, lunatis vel falcatis si conidiophoris adhaerentia, a basi plus minus rectis, 4-septatis, cellulis plures olei guttas continentibus.

*Hab.* in fossulis ( $1-2 \times 1-1.5$  cm. diam.) leviter depressis in viridi cortice *Pseudotsugae taxifoliae* (Lam.) Br., British Columbia et Oregon in America boreali.

Pycnidia occurring singly or more rarely in groups of two to four, erumpent, stalked, columnar, erect, 1-1.5 mm. high, cylindric above,  $125-200 \mu$  diam., sometimes more or less spreading at the base to  $300-500 \mu$ , the enlarged portion partly buried in the outer layer of the cortex, externally black, minutely scabrous, drying hard and brittle; ostiolum broadly circular, compressed and closed when dried; sporiferous locule lined with conidiophores, elongate, occupying the upper one-fourth to one-third of the column; the sterile basal portion composed of densely interwoven, branched, septate hyphae which have a tendency to become agglutinated and give the tissue a subgelatinous to cartilaginous character, darkened around the outer surface of the fruit body to form a thin black layer; conidiophores simple, one-celled,  $12-16 \times 2-2.5 \mu$ ; conidia hyaline  $35-60 \times 3.5-4.5 \mu$ , when lying free crescent-shaped or sickle-shaped, when attached to the conidiophores more or less straight at the basal end, 4-celled, each cell containing several oil drops.

Occupying small superficial sunken lesions,  $1-2 \times 1-1.5$  cm. diam. in the cortex of young, living, smooth-barked trees of *Pseudotsuga taxifolia* (Lam.) Br. British Columbia and Oregon.

Type collected near Bear Springs, Clackamas County, Oregon, Aug. 23, 1930, by J. S. Boyce (Cornell University, Department of Plant Pathology Herbarium No. 24008).

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# ZONATION IN ALLOMYCES ARBUSCULA<sup>1</sup>

WINSLOW R. HATCH

(WITH 5 FIGURES)

*Allomyces arbuscula* grown on agar and exposed to those conditions of light and temperature ordinarily obtaining in the laboratory shows a characteristic banding of the mycelium (FIG. 1). Zones of compact hyphal growth and heavy gametangial or sporangial production alternate with zones of diffuse hyphal growth in which the gametangia or sporangia are few and scattered.

In the formation of the heavy bands the advancing hyphae first divide dichotomously. These bifurcated hyphae then resume their forward growth but in this growth the arms of the dichotomies tend to parallel each other closely, failing in any notable divergence. This growth, however, is soon interrupted by the formation of numerous reproductive bodies which ultimately accumulate in such numbers as to form a ridge on the surface of the agar. Since the peak of this intense reproductive activity is achieved quickly and falls off slowly the ridge rises sharply in front, falls off gradually behind. At the point where the ridge flattens out the zone of diffuse growth begins. By marking the extent of mycelial growth every four hours it was discovered that the dense, heavily reproductive growth began between 4-8 in the morning, reached its peak about noon, and falling off during the afternoon and evening, ran out between 10-1 at night. The diffuse growth was thus limited to the midnight and early morning hours.

In searching for the cause of this zonation diurnal changes in light and temperature both offered plausible explanations. Light, however, was quickly ruled out by growing the fungus in absolute darkness. When growth rings continued to form it seemed certain that zonation could not be due to any day and night change in illumination. In this experiment Petri dish

<sup>1</sup> Botanical contribution from the Johns Hopkins University, No. 131.

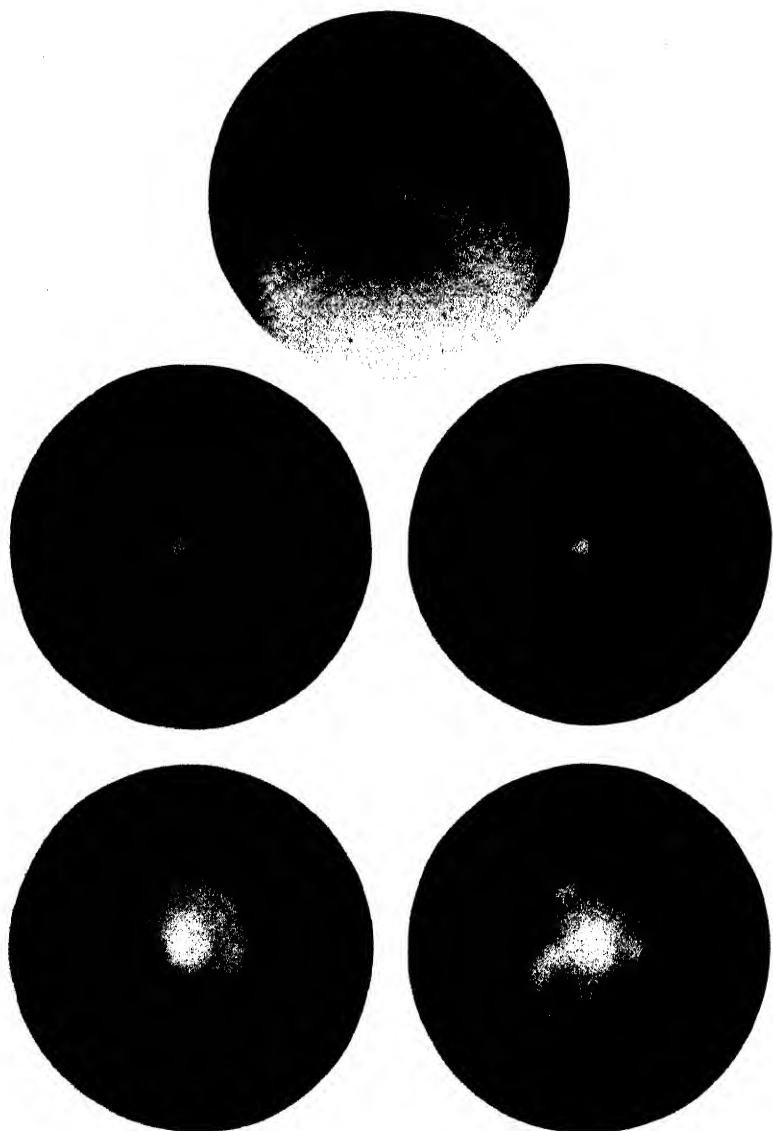


FIG. 1-5.

cultures of both sexual and asexual mycelia were placed in a specially designed dark room and left undisturbed for 7 days. Temperature was not controlled. Other cultures comparable in every respect were exposed to diurnal illumination in the greenhouse where the temperature was likewise variable. Growth rings formed in both instances.

In studying the relation of temperature to zonation cultures were placed in a constant temperature apparatus where the temperature could be held to a fluctuation of  $\frac{1}{2}^{\circ}$  C. The constant temperature apparatus used in this experiment had eight compartments each set at a different temperature. The temperatures used were  $7^{\circ}$  C.,  $13^{\circ}$  C.,  $17.5^{\circ}$  C.,  $22^{\circ}$  C.,  $26^{\circ}$  C.,  $30^{\circ}$  C.,  $34^{\circ}$  C. and  $37^{\circ}$  C. Into each of these eight compartments two sexual and two asexual cultures were placed. The apparatus was then closed and the cultures left undisturbed for 7 days. Other cultures, comparable in every respect, were left on top of the constant temperature apparatus where they were exposed to diurnal changes in temperature as well as light. When the apparatus was subsequently opened no semblance of rings could be seen in any culture grown therein (FIG. 2, 3). The controls on the other hand were characteristically banded. This would seem to prove conclusively that diurnal changes in temperature are responsible for zonation in *Allomyces arbuscula*.

The question next arises as to how great the change in temperature need be. To get at this a sexual and an asexual culture from the  $37^{\circ}$ ,  $34^{\circ}$ ,  $30^{\circ}$ , and  $26^{\circ}$  compartments were placed in the  $22^{\circ}$  compartment. This represented a change of  $15^{\circ}$ ,  $12^{\circ}$ ,  $8^{\circ}$  and  $4^{\circ}$  respectively. A sexual and an asexual culture from the  $7^{\circ}$ ,  $13^{\circ}$  and  $17.5^{\circ}$  compartments were likewise placed in the  $22^{\circ}$  compartment. This represented a change of  $15^{\circ}$ ,  $9^{\circ}$ , and  $4.5^{\circ}$  respectively. After this transfer the constant temperature apparatus was closed and left undisturbed for three days. When opened it was discovered that every culture that had been moved into the  $22^{\circ}$  compartment formed a single sharp ring (FIG. 5). The  $22^{\circ}$  cultures and those left undisturbed in their original compartments still failed to develop rings. A change in temperature of as little as  $4^{\circ}$  C. is then enough to induce ring formation. Furthermore, this change in temperature can be in either direction, up or down.

While the above experiment demonstrated a surprising temperature sensitivity in the mycelium it remained for a subsequent experiment to show just how sensitive the mycelium actually is to temperature changes. Cultures placed in a dark room where there was a daily fluctuation of only  $1\frac{1}{2}^{\circ}$  C. ( $18\frac{3}{4}^{\circ}$ – $20\frac{1}{4}^{\circ}$ ) continued to form rings; these rings, however, were less distinct than any seen heretofore (FIG. 4).

With the knowledge that only a degree or a degree and one-half change in temperature is necessary to cause ring formation the question next arises as to how long these temperature changes need to be. To test this another set of cultures were run in the constant temperature apparatus and again a sexual and an asexual culture were changed from each of the different temperature levels to the  $22^{\circ}$  compartment, but this time these cultures were only left at the  $22^{\circ}$  level for one hour before returning them to their original compartments. Controls were kept by leaving one sexual and one asexual culture in each compartment. A sharp ring formed in the transfers, none in the controls. Since it was already known that momentary changes up to 5–10 minutes did not cause ring formation this experiment proved that the time requirement in temperature changes lies somewhere between 5–10 minutes and 1 hour. By marking the extent of mycelial growth at the time of transfer, it was definitely ascertained that the heavy growth ring was set off soon after the transfer was made. This analysis, however, was not carried farther.

To the last three experiments the objection might be raised that in the transfer of cultures to one temperature from several others the momentary exposure to light might be significant. Accordingly the last experiment was repeated only the controls in the bottom of the several chambers were given the same exposure to light as the transferred cultures. Again no rings formed in the controls so it would seem that light in short sharp exposures is no more effective in causing zonation than longer, diurnal exposures.

The cause of zonation in fungi has been investigated by a great many workers in many different species and while zonation has been variously attributed to light, to media, or to more or

less inexplicable biological periodicities they are agreed, with but one exception, that temperature does not effect zonation. The exception has been described by Bisby<sup>1</sup> for *Fusarium discolor sulphureum* where temperature as well as light may cause zonation. In *Allomyces arbuscula* we have another exception—a very striking exception—for in this species temperature alone effects zonation, light causing no demonstrable effect whatever. Now it may very well be that temperature is an inconsequential factor in other fungi but the fact that in *Allomyces* temperature had to be held to less than a  $1\frac{1}{2}^{\circ}$  fluctuation before an effect could be demonstrated suggests that like treatment in other species may result in like results. In any event, any investigation of zonation must hereafter seem inconclusive unless temperature is very carefully controlled.

#### SUMMARY

1. Zonation in *Allomyces arbuscula* represents a periodic massing of hyphae and reproductive structures.

2. Under the conditions ordinarily obtaining in the laboratory, there is a diurnal rhythm in zonation, a heavy ring being laid down between 6<sup>+-</sup> A.M. and 12<sup>+-</sup> P.M., a diffuse one between 12<sup>+-</sup> P.M. and 6<sup>+-</sup> A.M.

3. Diurnal illumination shows no apparent causal relationship with ring growth.

4. Growth rings are caused by diurnal fluctuations in temperature.

5. A fluctuation between  $\frac{1}{2}^{\circ}$  and  $1\frac{1}{2}^{\circ}$  C. is enough to cause growth ring formation.

6. The knowledge that fungus mycelia may be extremely sensitive to temperature changes suggests that temperature may exert a more profound influence on zonation than has been assumed.

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<sup>1</sup> Bisby, G. R. Zonation in cultures of *Fusarium discolor sulphureum*. *Mycologia* 17: 89-97. 1925.



## EXPLANATION OF FIGURES

Fig. 1. A sexual mycelium showing the characteristic type of zonation found in cultures exposed to diurnal changes in light and temperature. Figs. 2 and 3. A sexual and an asexual mycelium respectively showing the complete lack of zonation characteristic of cultures grown at constant temperatures; *i.e.*, at temperatures held to a  $\frac{1}{2}^{\circ}$  fluctuation. These particular cultures were taken from the  $34^{\circ}$  C. compartment of the constant temperature apparatus. Fig. 4. An asexual mycelium showing the type of zonation induced by a daily fluctuation in temperature of  $1\frac{1}{2}^{\circ}$  C. Fig. 5. An asexual mycelium showing the single growth ring characteristic of those cultures in the constant temperature apparatus that experienced a single change in temperature during the course of their development. The change in this instance was only  $4^{\circ}$ , from  $26^{\circ}$  C. to  $22^{\circ}$  C.

## THE PERSISTENCE OF *HYPHOLOMA* *INCERTUM* ABOUT TREE STUMPS<sup>1</sup>

F. C. STEWART

Like many other agarics which grow on the ground about stumps or over buried wood *Hypholoma incertum* frequently appears year after year in approximately the same place. The writer has attempted to determine how long this fungus may continue to appear about a particular stump and the number of crops per season which it may produce. The data presented have been gathered from observations on four stumps in lawns in the city of Geneva, N. Y. The soil around all four of the stumps was a rather heavy and moderately fertile clay loam. The surface drainage was good. All were exposed to the sun.

### STUMP NO. 1

Stump No. 1 belonged to a shagbark hickory tree (*Carya ovata* K. Koch). The top of the tree, having died, was removed in 1915 leaving a stub 11 feet tall and 16 inches in diameter with three living branches at the top. In 1925, while the branches were still partly alive, the stub was sawed off even with the surface of the soil.

On August 6, 1918, a colony of *H. incertum* appeared close to the stump. This is believed to be the first occurrence of the fungus anywhere about the stump. Although the spot had been under observation by the writer since 1909 when the lawn was established, *H. incertum* had never been seen there, not even in the wet season of 1917 when several large gatherings of it were made elsewhere in Geneva.

Each year since 1918 it has been the writer's aim to record the size, location, and date of appearance of each colony appearing about the stump. Undoubtedly, the record of observations, shown in Table 1, is incomplete, particularly for the years 1921,

<sup>1</sup> Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 123, February 15, 1936.

TABLE 1

THE OCCURRENCE OF *Hypholoma incertum* ABOUT A HICKORY STUMP

Date	Number of sporophores	No. of crop	Location of colony with respect to the stump
1915	None		
1916	None		
1917	None		
6 Au. 1918	Several	1st	Close on the northeast
12 Je. 1919	Many	1st	Close on the east
14 Je. 1919	Many	1st	Close on the north
2 Jl. 1919	Many	2nd	Close on the north and east
23 Au. 1919	Many	3rd	Close on the north and east
22 Je. 1920*	A few	1st	Close on the east
4 Jl. 1920*	A few	2nd	Close on the east
23 Jl. 1920	Many	3rd	Close on the east
13 S. 1920	Many	4th	Not recorded
1921	None recorded	—	No record
7 Je. 1922	Many	1st	From stump southward 10 feet
14 Je. 1922	Thick over area 4 ft. in diam.	2nd	Close on the south
16 Je. 1922	About 25	2nd	Close on the northeast
16 Je. 1922	A few	2nd	15 ft. northeast
16 Je. 1922	Many	2nd	South and southeast over a distance of 25 ft.
22 Je. 1922	Many	3rd	From stump southward 10 feet
2 Jl. 1922	Many	4th	On the south
24 Jl. 1922	About 25	5th	On the south
9 Je. 1923	Many	1st	About 6 feet southwest
11 Je. 1923	Thick over area 6 × 10 ft. in diam.	1st	On the south and southwest
12 Je. 1923	Many	1st	On the west
2 Jl. 1923	Thick over area 6 ft. in diam.	2nd	On the south
9 Jl. 1923	Many	3rd	On the south
28 S. 1923	12	4th	On the south
26 Je. 1924	Many	1st	Extending southwesterly 23 feet
2 Jl. 1925	A few	1st	On the south
22 Jl. 1925	A few	2nd	On the southwest
27 Jl. 1925	Many	2nd	On the southwest
19 S. 1925	Many	3rd	Close on the southwest
2 Au. 1926	A few	1st	Close on the southwest
11 Au. 1926	Many	2nd	Close on the southwest
11 Au. 1926	A few	2nd	14 feet southwest
13 S. 1926	Several	3rd	Close to the stump
13 S. 1926	10	3rd	20 feet southwest

\* Exact date uncertain.

TABLE 1—*Continued*

Date	Number of sporophores	No. of crop	Location of colony with respect to the stump
1927	None recorded	—	No record
20 Je. 1928	7	1st	Close to the stump
27 Je. 1928	A few	2nd	Not recorded
1929	None recorded	—	No record
20 Je. 1930	Several	1st	Close to the stump
5 Je. 1931	A few	1st	10 feet northwest
8 Jl. 1932	50 or 60	1st	10 feet northwest
1933	None		
1934	None		
1935	None		

1924, 1927, 1930, and 1933, when the writer was away from Geneva most of the time during July and August. However, it is certain that the fungus persisted at least 14 years (1918 to 1932) and produced from one to five crops each season except, possibly, in 1921, 1927, and 1929. Large colonies were seen in 1919, 1920, 1922, 1923, 1924, 1925, and 1926. There were two small colonies in 1928 and a single small one in each of the four years 1918, 1930, 1931, and 1932. None have been seen since 1932. On June 25, 1935, when the fungus was appearing elsewhere in the vicinity none occurred about the hickory stump. It seems to have run its course there.

Clearly, the time of appearance of a crop of the fungus was determined primarily by the rainfall. The large crops closely followed rain periods of three to five days with a total rainfall of about 1.5 inches or more. They occurred at various times between June 7 and September 19. Sometimes, when a crop consisted of colonies at different points the several colonies did not all appear on the same day as, for example, in the second crop of 1922 and the first crop of 1923 (Table 1). Sometimes a crop occupied almost exactly the same area or areas as the preceding one, but more often the later crop had a somewhat different location.

Prior to 1922 all of the colonies were located close about the stump. From 1922 on some were close to the stump while others were found at distances of several feet from the stump. In the second crop of 1922 sporophores of the fungus were thinly scattered along a strip 1.5 to 3 feet wide extending from the stump toward the southeast to a distance of 25 feet. At other times similar long narrow colonies of scattered plants extended toward the south and southwest, indicating the course of shallow roots. However, none of the roots showed at the surface of the soil.

The abortive sporophores of some polypore, probably *Fomes applanatus* (Pers.) Wallr., on the stump from 1926 to 1928, were the only indication of the presence of any wood-inhabiting fungus which might have been a competitor of the *Ilypholoma*.

#### STUMP NO. 2

Stump No. 2 belonged to a sugar maple tree (*Acer saccharum* Marsh.). It stood in a 4-foot-wide strip of lawn between a concrete sidewalk and the street curb. The tree died from an undetermined cause early in the spring of 1923 after putting out a few leaves. It was felled the following summer. The stump was 15 inches in diameter. The first appearance of *Ilypholoma incertum* here was on June 12, 1923, when a small colony was found on the east side of the stump. On June 26 of the following year a single colony containing several plants appeared in the same place. In 1925 the fungus was seen twice—on July 17 north of the stump and about July 1 when neither the date nor the location was recorded. Finally, a colony containing several sporophores was recorded on July 22, 1926, and none since.

Here, the fungus was in severe competition with *Coprinus micaceus* Fries, which first appeared in May, 1924, and was plentiful all around the stump each season during the next nine years. On June 22, 1926, sporophores of the two species grew in close association.

#### STUMP NO. 3

Stump No. 3 belonged to an elm tree (*Ulmus americana* L.). It was under observation from the time the tree was felled in the autumn of 1917 until the autumn of 1933 when it had become a

mere shell filled with powdered rotten wood. This stump was 4 feet in diameter and 12 to 18 inches tall. *Hypholoma incertum* began to appear in 1922 producing seven separate crops that year, nine crops in 1923, one in 1924, two in 1925, and one in 1928. Some colonies were close to the stump while others were at various distances up to 20 feet from it. A tendency was shown to follow the course of hidden roots as in the case of the hickory stump. Heavy watering of the stump and surrounding soil during spells of dry weather is partly responsible for the large number of crops produced in 1923. During the same period large colonies of *Coprinus micaceus* Fries, and *Psathyrella disseminata* Fries occupied the same areas as the *Hypholoma* and must have competed with it for nourishment. Between May 15 and December 3, 1923, 38.25 pounds of *Coprinus micaceus* caps were gathered about this stump.<sup>2</sup>

#### STUMP NO. 4

The fourth stump belonged to a large apple tree (*Malus domestica* Borkh.). It had been dug out and the hole filled in 1916 or earlier. Nothing is known about the mycology of the spot prior to June 14, 1917, when large numbers of *Hypholoma incertum* sporophores were discovered growing there in an ellipse of 6 X 4 feet. A second large crop was found covering the same area on June 25, 1917. The third crop, a basketful of fine specimens, was gathered from the same area on July 17, 1917. A few sporophores which appeared on September 7 represent the fourth and last crop of 1917.

In 1918, also, there were four crops, namely, a dozen large sporophores on May 21, a large number on May 28, a basketful on August 6, and a large crop on August 14.

In 1919 two crops were recorded—several sporophores on May 30 and a large crop on August 23.

In 1920 a basketful was recorded on June 24, and in 1922 "some" on June 11.

No competing fungus was seen here during the six seasons covered by the observations.

<sup>2</sup>Stewart, F. C. The mica ink-cap or glistening *Coprinus*. New York State Agr. Exp. Sta. Bull. No. 535: 14. 1926.

## DISCUSSION

From these observations it appears that the fungus may persist from 4 to 14 years and the number of crops per year may vary from one to nine. The amount and distribution of the rainfall largely determine the number of crops per year; but the cause of the wide variation in the length of the period of persistence is not so readily explained. In the first place it is uncertain to what extent new colonies come from mycelium living from year to year in the roots of the stump and to what extent they may result from annual reinfection by means of spores. The tendency of the fungus to appear at approximately the same point in successive years suggests a perennial mycelium. On the other hand, the frequency with which the fungus occurs indicates that the conditions necessary for infection by spores are not difficult to satisfy. Hence, it seems probable that both methods of sporophore production may be in operation.

In the case of the hickory stump, where the fungus persisted for 14 years, the period of persistence was prolonged, probably, by the gradual dying of the tree. Some roots must have died several years before all were dead, thereby furnishing a succession of roots in suitable condition to become a substratum of the fungus. Although *Hypopholoma incertum* sometimes appears about a tree before all of the parts above ground are dead, it has not been proved, so far as the writer knows, that the fungus is capable of attacking living roots.

It is possible that the competition and antagonism of other wood-inhabiting fungi were important factors in determining the length of the period of persistence. So far as above-ground indications go there was less interference by other fungi around the hickory stump than around either the maple stump or the elm stump, but there is no means of knowing to what extent the unseen roots were invaded by the mycelia of other fungi which did not appear above ground.

Other factors involved are the differences in the sizes of the stumps and in the species of trees to which they belong.

# ASCOCALYX ABIETIS AND BOTHRODISCUS PINICOLA <sup>1</sup>

J. WALTON GROVES

(WITH 6 FIGURES)

During the summer of 1934 a discomycete was collected on *Abies balsamea* in the Temagami Forest Reserve, Northern Ontario, which has been identified as *Ascocalyx Abietis* Naumov. It was found associated with fruiting bodies of *Bothrodiscus pinicola* Shear, and subsequent cultural studies have shown this to be the imperfect stage. The study of this association was undertaken in connection with a more general study of conidial relations in the Dermateaceae. Since the connection of the two stages and the relationships of *Ascocalyx* are of some special interest, it seems desirable to present these results at this time.

In the Temagami region *Bothrodiscus pinicola* occurs commonly on lower dead branches, or on branches of fallen trees of *Abies balsamea*, and has not been observed on any other host. The fructifications are especially noteworthy because of the unusual pezizoid form of the stroma. They are black, or dark greenish when moist, and are quite conspicuous. The spores are produced in ovoid locules in the disc of the stroma, from which they emerge in small glomerules, forming whitish masses on the disc.

The perfect stage is found closely associated with the imperfect, but is less conspicuous and is usually not abundant. The apothecia are black with a lighter colored margin, and in the dry condition are more or less infolded and inconspicuous, but expand

<sup>1</sup> Contribution from the Department of Botany, University of Toronto. The writer wishes to express his appreciation and gratitude to Professor H. S. Jackson, under whose direction the work was carried on, for his helpful suggestions and criticism; to Dr. C. L. Shear for his generous co-operation in re-examining the type of *Bothrodiscus pinicola*; to Mr. E. W. Mason for examining the type of *Cenangium pithyus* Berk. & Curt., and for permission to quote from his notes; to Dr. M. W. Bannan for identifying the wood in the type collection of *Bothrodiscus pinicola*, and in the specimen of *Fusisporium Berenice* in N. Am. Fung. 376a; and to Dr. D. H. Hamly for the photograph reproduced in figure 2.



when moistened. They commonly occur in small clusters, seated on a rounded, black, rather horny stroma. When fully mature this stroma is rather loosely attached to the substrate, readily

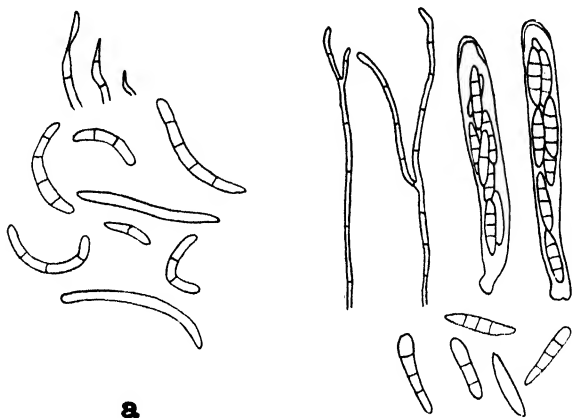


FIG. 1. a, conidiophores and conidia; b, asci, ascospores, and paraphyses. Drawn with the aid of a camera lucida.  $\times 400$ .

becoming detached, and consequently the mature apothecia are easily lost in herbarium specimens unless care is exercised in handling them.

#### HISTORICAL

The conidial stage has been known for some time. The earliest record which has been noted is that of Berkeley (1875a), who described it as *Fusisporium Berenice* Berk. & Curt., having misinterpreted the structure, considering it to be an imperfect fungus parasitic on a decayed *Peziza*. He described the spores and noted that they were found in small balls, but failed to realize that the pezizoid fruiting body was itself the conidial fructification. The type was collected at Boston, Mass. Two collections were distributed under this name in Ellis' North American Fungi, 376a and 376b. The former was collected at Newton, Mass., and the latter at West Chester, Pa., and in each case the host is *Abies*.

The Massachusetts collection (376a) was made by Dr. Farlow and presumably identified by him. On the label it is suggested that the fungus might be the pycnidial form of some *Cenangium*, possibly *C. pithyum*, which was also described by Berkeley (1875b). In order to determine if *Ascocalyx Abietis* were

identical with *Cenangium pithyum* Berk. & Curt., Mr. E. W. Mason of the Kew Herbarium kindly examined the type of *Cenangium pithyum* and compared it with specimens of *Ascocalyx Abietis* and *Bothrodiscus pinicola* from the herbarium of the University of Toronto. He found that the type of *Cenangium pithyum* Berk. & Curt. consisted of five fruiting bodies which were identical, not with *Ascocalyx*, but with the conidial stage, *Bothrodiscus*. The following quotation is from a report by Mr. Mason dated January 7, 1936:

"*Cenangium pithyum* Berk. & Curt. is the same fungus as Toronto 8287 labelled *Bothrodiscus pinicola* Shear. The four spores figured by Berkeley are pycnosporos and not ascospores, so that it can be confidently stated that the diagnosis of *Cenangium pithyum* Berk. & Curt. refers to the pycnidial condition and not to the perfect stage of this fungus."

The locality of the type collection is given only as New England, and the host again is *Abies*.

Shear (1907) properly interpreted the structure and described the fungus as *Bothrodiscus pinicola*. In this description the host was said to be *Pinus virginiana*, but this was evidently an error on the part of the collector. Dr. Shear, in a letter, expressed doubt that the host was *Pinus* and sent a bit of the wood from the type collection, and when this was examined microscopically by Dr. M. W. Bannan it proved to be not *Pinus*, but *Abies*.

Naumov (1915) reported a conidial fungus on *Abies sibirica* in Russia, which he described as *Pycnocalyx Abietis*. He considered that this fungus was related to *Bothrodiscus pinicola*, but differed in that the conidia became septate, whereas in Shear's description they were said to be continuous.

It has been found in the Temagami collections that the septation of the conidia is very variable, and that the spores may be one to six celled. In this connection Dr. Shear re-examined the original slide of the type of *Bothrodiscus pinicola* and found that the conidia were now perfectly clear and free from guttules, and showed distinctly three to five septa. Thus there can be little doubt but that *Bothrodiscus pinicola* and *Pycnocalyx Abietis* are identical.

The perfect stage was described by Naumov (1925) as *Asco-*

*calyx Abietis*. He had observed it growing on *Abies* in close association with his *Pycnocalyx Abietis* and inferred that the two stages were genetically related, but he did not prove this connection by cultures. His description and figures agree well with the Canadian collections. He mentioned having collected it twice on *Abies*, the apothecia being immature in each case and brought to maturity in a moist chamber in the laboratory. He also stated that he found a mature form on *Larix* once, but he did not state whether or not the imperfect stage was also collected on *Larix*. The evidence so far accumulated regarding the host relations of this fungus in North America would indicate that it is specific to *Abies*. Possibly a closely related form may occur on *Larix*, or further investigation may show that *Ascocalyx Abietis* is not confined to *Abies*.

#### CULTURAL STUDIES

Cultures were obtained from both ascospores and conidia and were grown on 2 per cent malt extract agar and on sterilized twigs of the host. The cultural characters were similar in both ascospore and conidial cultures. On malt extract agar the growth is slow, the colonies spreading but slightly and tending to become heaped up. The surface of the colonies is downy to felty, often

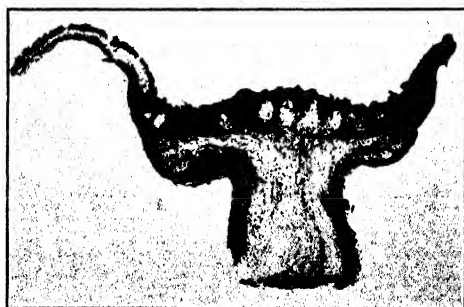


FIG. 2. Photograph of a freehand section of a fruiting body of *Bothrodiscus pinicola*.  $\times 35$ .

with irregular, white, cottony tufts. The color is variable, from almost white to shades of yellowish-green or olivaceous, "Marguerite yellow" to "buffy olive." Conidial fructifications are produced fairly abundantly in both ascospore and conidial cultures. They are usually typical in form, color, and con-

sistency, of the fructifications found in nature, but sometimes the outside has a downy or tomentose covering. The spore masses are usually very abundant, sometimes forming long cirrhi composed of the small balls of spores.

The twig cultures were set up in the following manner. Three healthy twigs of *Abies balsamea*, about 7–10 cm. in length, were selected and placed in a 300 cc. Erlenmeyer flask with about 25 cc. of water. They were sterilized for half an hour in the autoclave at 15 pounds pressure, and inoculated by placing bits of agar and mycelium in slits which had previously been cut in the bark. The flasks so prepared were kept on a shelf in the laboratory at room temperature and in diffuse light. It was thus possible to remove a twig for examination and leave the others, to observe further development, and also to determine if the perfect stage would develop later. Although after two months fruiting bodies of the imperfect stage were well developed in cultures from both ascospores and conidia, the perfect stage did not appear in any of the cultures, some of which were eight months old.

On the twigs in culture there was produced a thin, cottony, somewhat tufted, aerial mycelium, greyish-green or yellowish-green in color, and sometimes spreading over the twig. Conidial fructifications were formed abundantly in both ascospore and conidial cultures. They were quite typical of those found in nature, sometimes larger, and often covered with a greyish-green tomentum (FIG. 6). The spore masses were usually very abundant, completely filling the cup. Sometimes they did not sporulate, but the stroma elongated into a structure such as that shown at the upper left of figure 6. Sections of this one showed that at the wider central part there was a large cavity with typical pycnidial locules opening into it and spores had been produced, but the peridium had not ruptured and had continued to grow, forming another stalk-like part above the cavity. Others similar to this one have been observed to sporulate at the tip of the second stalk in the usual manner.

Polysporous cultures were used in the hope of facilitating the development of the perfect stage in case the fungus might be heterothallic. However, since the perfect stage did not appear in any of the cultures, there is no information on this point. No microconidia have been observed.

In studying the structure of the fruiting bodies of both perfect and imperfect stages in nature and in culture, freehand sections and crushed mounts have been used entirely. The sections were mounted in cotton blue in lacto-phenol, or stained with eosin or safranin and mounted in glycerine jelly.

#### TECHNICAL DESCRIPTION

As the Russian article is not readily available, it seems advisable to include a description with synonymy, based on the Canadian material.

ASCOCALYX ABIETIS Naumov. Bolesni Rast. **14**: 138. 1925.

*Fusisporium Berenice* Berk. & Curt. Grevillea **3**: 147. 1875.

*Cenangium pithyum* Berk. & Curt. Grevillea **4**: 4. 1875.

*Scleroderris pitya* Sacc. Syll. Fung. **8**: 596. 1889.

*Bothrodiscus pinicola* Shear. Bull. Torrey Club **34**: 312. 1907.

*Pycnocalyx Abietis* Naumov. Bull. Soc. Oural. Sci. Nat. Trud. Bur. Mykol. **35**: 34. 1915.

Apothecia erumpent, scattered, usually in clusters of 3-6, arising from a rounded, black, basal stroma, circular or slightly wavy in outline, slightly narrowed below, 0.3-1.0 mm. in diameter, the clusters up to slightly over 1 mm. in height, dull black externally, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium concave, becoming plane, smooth, gray to blackish, somewhat fleshy, surrounded by a light gray margin which is infolded when dry and expanded when moist; tissue of the basal stroma compact, pseudoparenchymatous, composed of irregular cells 6-12  $\mu$  in diameter, fairly thick walled, hyaline or pale yellowish, darker toward the outside, the cells becoming more elongated in the stalk and arranged in more or less vertically parallel rows, the upper part containing a zone of dark colored, irregular cells up to 15  $\mu$  in diameter, this zone being up to 150  $\mu$  thick in the center and curving up around the hymenium, becoming thinner toward the margin; excipulum outside this zone consisting of very thick walled, lighter cells with the walls grown together and the outlines indistinct; subhymenium a zone of closely interwoven, indistinct, yellowish hyphae, 3-6  $\mu$  in diameter; asci cylindric-clavate with a very short stalk, eight spored, 65-100 (-125 Naumov)  $\times$  9.5-11.0  $\mu$ ; ascospores hyaline, elongate-cylindric, to subclavate, tapering slightly toward the ends, one to four celled, mostly straight, irregularly biseriate, 14-22  $\times$  4-5  $\mu$ ; paraphyses hyaline, filiform,



FIG. 3-6. 3, apothecia of *Ascocalyx Abietis*; 4, apothecia opened out after being moistened; 5, imperfect stage, *Bothrodiscus pinicola*; 6, imperfect stage developed on a twig of *Abies balsamea* in culture.  $\times 4$  approx.

septate, branched,  $1.5\text{--}2.0\ \mu$  in diameter, scarcely or not at all swollen at the tips, and not forming an epithecium.

Specimens examined. University of Toronto Herbarium. On *Abies balsamea*: 7267, 7284, 7285, 7821, 7890, 7893, Temagami Forest Reserve, Ontario.—6964, Bruce Co., Ontario.—Inlet, N. Y.

Conidial stromata erumpent, usually rather thickly scattered, mostly single, or two or three together, occasionally found arising from the same basal stroma as the apothecia, at first almost globose, elongating and becoming obconic, opening at the tip and spreading out, becoming cup-shaped or pezizoid, up to 2 mm. in diameter and 1 mm. in height, externally dark brown to black, sometimes olivaceous when moist, leathery to horny in consistency, becoming more fleshy-leathery when moist; pycnidial cavities immersed in the disc of the stroma, ovoid, about  $25\text{--}75 \times 75\text{--}100\ \mu$ ; tissue pseudoparenchymatous, composed of irregular cells  $5\text{--}15\ \mu$  in diameter, hyaline or yellowish, becoming darker toward the outside, arranged in more or less vertically parallel rows which spread out obliquely in the upper part, the peridium composed of thicker walled cells which are very dark at the outside; conidiophores hyaline, septate, not observed branching, tapering to a slender point,  $8\text{--}12 \times 1.5\text{--}2.5\ \mu$ ; conidia hyaline, elongated to subfiliform, ends rounded or rather bluntly pointed, variously curved to almost straight,  $1\text{--}6$  celled,  $16\text{--}44 \times 3\text{--}5\ \mu$ , emerging and adhering together in small glomerules.

Exsiccati: Ellis, N. Am. Fung. 376a, 376b.

Specimens examined. University of Toronto Herbarium. On *Abies balsamea*: 4303, 4304, 7284, 7892, 8287, Temagami Forest Reserve, Ontario.

U.S.D.A. Bur. Pl. Ind. Path. and Myc. Coll. On *Abies Fraseri*: Ex. 60729, Indian Gap, Great Smoky Mts., N. Carolina. Det. C. L. Shear.

Herbarium University of Michigan. On *Abies balsamea*: F.p. 274, Isle Royale, Michigan. Coll. and det. A. H. Povah.

U.S.D.A. Forest Pathology. On *Abies balsamea*: 50975, Marlow, New Hampshire. Coll. and det. J. R. Hansbrough.

In the North Carolina and New Hampshire collections, apothecia of *Ascocalyx Abietis* were present, but they were all immature and no asci could be found.

## DISCUSSION

*Ascocalyx Abietis* would belong in the family Dermateaceae as ordinarily interpreted. Naumov (1925) suggested that it was close to *Tympanis*, chiefly on the basis of its color and consistency. However, the color is probably not extremely significant, the consistency is really closer to *Dermatea* than to *Tympanis*, and in other characters such as tissue structure, character of the asci and ascospores, and type of conidial stage, it shows no similarity to *Tympanis*. It would seem that *Ascocalyx Abietis* is closely related to the fungi which have been placed in the genus *Crumenula* in the sense of Rehm (1889), and that evidence for this relationship is to be found in both the perfect and imperfect stages. Rehm (1889) characterized *Crumenula* as including the forms having two to four celled ascospores and fine hairs on the outside of the apothecium. He described two species, *C. pinicola* (Reb.) Karst. and *C. sororia* Karst.

Lagerberg (1913) described another species, *C. abietina*, on *Picea excelsa* in Sweden. Many features of this fungus are similar to those of *Ascocalyx Abietis*, the color and consistency of the apothecia, the lighter colored, infolded margin, gray hymenium, and the character of the asci and ascospores. Associated with this discomycete he found an imperfect known as *Brunchorstia destruens* Erikss., which had previously been considered to be the imperfect stage of *Cenangium Abietis* (Pers.) Rehm. He suggested that it might be the imperfect stage of *Crumenula abietina*.

This was proved to be correct by Jørgensen (1931) who cultured *Crumenula abietina*, *C. pinicola*, *Brunchorstia destruens*, and *Cenangium Abietis*. He showed that cultures of *Crumenula abietina* and *Brunchorstia destruens* were identical, and while he was unable to obtain any imperfect stage in culture from *C. pinicola* he concluded that it was distinct from *C. abietina*.

No specimens of *C. abietina* have been available for comparison, but the specimen of *C. pinicola* in Rehm's Ascom. 2054 was examined. The material was very scanty, and while the apothecia were of a more reddish-brown color and more hairy than those of *Ascocalyx Abietis*, the asci and ascospores were very similar in appearance but differed slightly in size. A comparison of figure 1b with Jørgensen's figure 10 (1931, p. 232) shows the



similarity between asci and ascospores of *Ascocalyx Abietis* and *Crumenula abietina*.

Further evidence for the relationship of *Ascocalyx* and *Crumenula* is provided by a comparison of the conidial stages, *Bothrodiscus pinicola* and *Brunchorstia destruens*. The form of the conidia is very similar in both fungi as may be seen by a comparison of figure 1a and Jørgensen's figure 7, p. 230, and 12, p. 232. Van Luijk (1927), who made a study of *Brunchorstia destruens* in culture, speaks of the conidia as issuing in small balls ("pfropfen"), which is a highly characteristic feature of *Bothrodiscus*. The fruiting body of *Brunchorstia* is much smaller than that of *Bothrodiscus*, but is similar in consistency and general structure as determined from an examination of Weese, Eum. Sel. Exs. 701. It is suggested that the fruiting body of *Brunchorstia* is properly interpreted as a stroma in which only one pycnidial cavity is developed, whereas in *Bothrodiscus* several cavities are formed in the one stroma.

However, while there is good evidence that *Ascocalyx Abietis* is closely related to *Crumenula abietina* and *C. pinicola*, it is thought inadvisable to transfer it to *Crumenula* in view of the present uncertain status of that genus. The genus *Crumenula* was established by DeNotaris (1861) based on a fungus collected on *Calluna vulgaris* which he considered to be *Cenangium Urceolus* Fries. This fungus, according to DeNotaris' description, evidently possessed urceolate apothecia and filiform ascospores, and the genus was used in this sense by Phillips (1893). The concept of the genus was widened by Karsten (1869, p. 170) to include *Peziza pinicola* Rebent., and Rehm (1889) emended *Crumenula*, considering *Crumenula pinicola* (Rebent.) Karst. as the type of *Crumenula*, and *Cenangium Urceolus* Fries as the type of the genus *Godronia*. Nannfeldt (1932) has combined all these forms under the generic name *Scleroderris*, typified by *Cenangium Ribis* Fries.

The taxonomy of the group is obviously in a state of considerable confusion at present. It is clear, however, that Rehm's treatment of these genera is not in accord with the type concept as defined in the International Rules of Botanical Nomenclature. It may be that *Crumenula* will prove to be a synonym of *Sclero-*

*derris*, but if the name *Crumenula* is valid it must be reserved for the group of fungi typified by *Crumenula Urceolus* DeNotaris. The writer believes that *Ascocalyx Abietis* is generically distinct from fungi such as *Godronia Urceolus*, as commonly understood, and *Scleroderris Ribis*, but that it is probably congeneric with fungi such as *Crumenula abietina* Lagerberg. Therefore, since it would seem that *Crumenula Urceolus* DeNotaris, the nomenclatural type of the genus *Crumenula*, is not congeneric with *Crumenula pinicola* (Reb.) Karst. and related species, it would appear that the genus *Ascocalyx* is valid for the fungus studied here, and probably also for the species included in the genus *Crumenula* in the sense of Rehm.

## SUMMARY

The genetic connection of *Ascocalyx Abietis* Naumov and *Bothrodiscus pinicola* Shear has been established by cultures.

*Ascocalyx Abietis* is probably closely related and congeneric with the fungi which have been placed in the genus *Crumenula* in the sense of Rehm.

*Crumenula*, as used in this sense, is not based on the nomenclatural type of the genus, and therefore it is concluded that *Ascocalyx* is a valid genus.

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## NOTES ON BOLETES. V

WALTER H. SNELL

In spite of a generally unsatisfactory season in New York in 1935 because of the severe drought, the past year or more has yielded information upon the boletes that is of great interest and importance. This new information has come chiefly from the study of specimens received from other mycologists or collectors. The most interesting material was the following:—several specimens from Pennsylvania, collected by Miss Esther A. Dick, one of the writer's graduate students; a new species and genus from Tennessee sent by Dr. L. R. Hesler; several collections from the environs of Ottawa by Mr. I. L. Connors and Dr. F. L. Drayton; a large amount of material from Manitoba sent by Dr. G. R. Bisby; a few important collections from Florida made by Mr. H. C. Beardslee; and especially a large number of the bolete collections in the University of Michigan Herbarium made by the late Dr. C. H. Kauffman, which were very kindly loaned by Dr. E. B. Mains.

Among the most interesting collections or distributional data not mentioned elsewhere in this paper, may be mentioned the following items.

(1) In New York, near Ausable Chasm, the writer found *Boletus Atkinsoni* and *B. variipes* in quantity, *B. hemichrysus* for his first time, and *B. impolitus*. This latter species was found again at Riverside.

(2) In the Manitoba material there were many species reported heretofore only in eastern North America, and most interesting of all, *B. mirabilis* heretofore known only from Washington and Oregon.

(3) *B. subalbellus* and a species that appears to be *B. albidus* subsp. *eupachyypus* was sent in by Mr. Beardslee from Florida.

(4) In the Kauffman material were collections from the Atlantic to the Pacific, providing valuable distributional data, and including a number of new species, mostly tentatively named by him.

Of known species, perhaps the most interesting were *B. mirabilis* from the Pacific Coast, *B. albidus* subsp. *eupachypus* in the East, and *B. edulis* subsp. *pinicola* in Wyoming.

#### BOLETUS CALOPUS and BOLETUS PACHYPUS

There has long been much uncertainty concerning *B. calopus* and *B. pachypus*. In this country, the uncertainty has concerned their occurrence on this side of the Atlantic. Peck listed them as reported here by others, but he did not collect them. Others have identified them only tentatively. In Europe, the uncertainty has concerned the correct application of the specific names. As might be expected, the clearing up of the situation in Europe has resulted in a clarification of the American situation likewise.

Konrad<sup>1</sup> decided that the name *pachypus* no longer should have a place in mycological nomenclature, because of the confusion resulting from its retention. In brief, he has decided that *B. pachypus* of most writers is *B. calopus* Fries, of which *B. olivaceus* (Schaeff.) Fries is only a synonym. This species has a brownish to olivaceous pileus, and a beautifully reticulated scarlet-, rosy- or purplish-red stipe, usually yellow at the apex. A closely related species is *B. albidus* Roques, pale in color, with stipe pale and not at all red or reticulated. More or less between these two is a species with pileus pale olivaceous to creamy yellowish to hazel, or perhaps cinnamon-brown, and a stipe yellowish at the apex, below dingy yellow more or less tinged or streaked with red, and a dark olivaceous-reddish base. This Konrad calls *B. albidus* subsp. *eupachypus*.

Whatever others may think of this disposition of former difficulties in this group, it works out well with American forms. The correct naming of anything near these species has heretofore been difficult. For example, Kauffman called some of his collections *calopus* and some *pachypus*, after changing his mind one or more times, and finally tentatively named two collections *B. dissimilis* n. sp.—most aptly. I have had similar experiences. In the light of Konrad's work, the situation now seems simple. We apparently have the true *calopus* in this country, but it is rare, and we also most certainly have Konrad's *B. albidus* subsp.

<sup>1</sup> Konrad, P. Notes critiques sur quelques champignons du Jura. Bull. Soc. Myc. Fr. IV, 45: 35-77. 1929.

*eupachypus*—or *B. eupachypus* Konrad, as many will prefer to call it. Kauffman's excellent notes, photographs and drawings make it very plain that this species occurs from Nova Scotia to Michigan. What I thought in "Notes on Boletes. I"<sup>2</sup> might be *B. rhodoxanthus* Kalchbr. is possibly this species.

#### NEW FORMS

The writer hesitates to multiply the number of forms (*formae*) and varieties with distinctive names, because of the ease with which one develops the habit of interpreting slight variations as definite taxonomic units. On the other hand, there are cases such as those below, in which the variations from the typical manifestation of the species are so definite that there is often a question as to whether or not they are distinct species. In order to avoid the multiplication of the number of species until sufficient information is at hand to make it compulsory, and to use the species concept on broad lines rather than on narrow differences, it seems best to designate the most outstanding of these variations as forms or varieties. In these cases, for the present the word "form" is used instead of "variety" as making no commitment as to the actual status of the variable segregate under consideration, until further information is available.

#### *B. CASTANEUS* f. **purpurinus** forma nov.

There has been found both by myself in New York and by Kauffman in Michigan a bolete that grows in the same habitat as *B. castaneus*, and is exactly like it except for the reddish-purplish instead of castaneous color, and in the clothing of the pileus being somewhat more pilose-tomentose.

#### NEW FORMS OF *B. FELLEUS*

In the writer's experience, the common *B. felleus* is typically partial to soil under hemlocks and to badly rotted hemlock stumps and logs. On the other hand, there are found under oaks and other hardwoods three puzzling forms which resemble *B. felleus* for the most part, especially in their bitter taste, but which seem to be best disposed of as forms of it.

Forma **plumbeoviolaceus** forma nov. was called to the writer's

<sup>2</sup> Mycologia 24: 334-341. 1 fig. 1932.

attention by A. B. Hatch in the Black Rock Forest near Cornwall, N. Y. It is distinctive as follows:—entire plant very hard and firm, especially when young, never as large as the typical form, pileus tomentose with a velvety appearance, quite violaceous when young and becoming a dull violaceous-purplish-gray or even duller, margin sterile, tubes remaining white for a long time and maturing their spores and becoming flesh-colored only very slowly, and with the stipe pallid to brownish or violaceous and often only very slightly reticulate.

It has since been found by Miss Esther A. Dick near Reading, Penn., and Kauffman also collected it in the District of Columbia and in Tennessee. Kauffman had hesitated between calling it a new species and a variety of *felleus*. Inasmuch as the above name given to it has been used by myself and some friends for some years, I am retaining it instead of changing it to the one Kauffman applied to it.

Forma **rubrobrunneus** forma nov. was found in 1935 under oaks near Round Lake and at Ausable Chasm, N. Y. Like the preceding, it is very firm and hard, and with velvety-appearing surface, sterile margin, and with late-maturing tubes. In color it is dull chocolate-brown to rich deep reddish-brown.

Forma **albiceps** Kauffman forma nov. was tentatively named as a distinct species "near *B. felleus*," but in my opinion it fits into the scheme mentioned above, as here named. It is at first closely mealy on the pileus and then glabrous, and is white throughout. It has been found only in Michigan.

#### NEW GENUS AND NEW SPECIES

The only parts of this country which have been thoroughly searched for boletes are New York State by Peck, the environs of Brattleboro, Vt., by Frost, and Mt. Gretna, Penn., by McIlvaine. Peck and Murrill named sporadically communicated forms from certain localities in the South, Middle West and the Pacific Coast. The northeastern states are now yielding newly found known species and even some new ones, and the certainty that many new species would be found in other parts of the country as soon as anyone began collecting these fungi there, is being borne out by what follows.

**Polyporoletus** gen. nov.

Carpophora suberosa, tenace, polyporoidea; tubuli inseparabilibus brevissimis, decurrentibus; stipite paululum crasso, eccentrico; sporis subglobis, brevi-verrucosis vel echinulatis.

Carpophore corky, tough, polyporoid; tubes inseparable, very short, descending the stipe to base in places; stipe stout, eccentric; spores subglobose, short-verrucose or echinulate.

**Polyporoletus sublividus** sp. nov.

Pileo firmo, suberoso, plano-convexo, e tomentoso fibrilloso, in disco subglabro, livido-olivaceo, in margine rubro-purpureo, 5 cm. lato; carne dilute cyanea vel violacea, infra cutem rubro-purpurea, sapore grato; tubulis difficiliter separabilibus, longe decurrentibus, primo flavis vel ochraceis, deinde brunneis, purpureo-tinctis, brevissimis; poris magnis, inaequalibus; stipite eccentrico, subglabro, reticulato, e livido-violaceo purpureo, flavo-olivaceo-velutino, spongioso; sporis subglobis, hyalinis, minute brevi-verrucosis, 7-10  $\mu$ .

Pileus firm and corky, nearly plane, 5 cm. broad. Surface tomentose on the margin, elsewhere fibrillose, nearly glabrous on disc; livid olive, reddish-purple on the margin. Flesh pale bluish or violaceous, more reddish-purplish under the cuticle; taste pleasant. Tubes hardly if at all separable, long-decurrent, at first yellow or ochraceous, later brownish with a purplish tinge, very short, 1-2 mm. long; mouths large, irregular and more or less uneven. Stipe eccentric, almost lateral, basically nearly glabrous, coarsely reticulate from walls of tubes, in part to base of stipe; basically livid to violaceous-purplish, covered with a yellowish-olivaceous velvetiness in places; within spongy, colored like flesh of pileus; 4 cm. long, 18-25 mm. thick. Spores subglobose, hyaline, minutely short-verrucose or echinulate, 7-10  $\mu$ . Cystidia scarce, clavate, few slightly rostrate, hyaline, 35-40  $\times$  8-10  $\mu$ .

On soil in oak-pine woods, near Allardt, Fentress County, Tennessee. Coll. A. J. Sharp and J. K. Underwood; comm. L. R. Hesler *via* L. O. Overholts. No. 536 in Herb. WHS.

This genus is polyporoid in its toughness and corkiness, and short tubes. It also is very close to *Gyrodon* of Europe in its short tubes and more or less dentate pores. It differs from *Gyrodon*, however, in being corky and tough, in having a thick, eccentric stipe, and especially in its subglobose, verrucose spores. These characters seem to provide sufficient justification for the erection of a new genus.



***Boletinus squarrosoides* Snell & Dick, sp. nov.**

Pileo plano-convexo depressoque, cum fuscis, teretibus, fibrillosis squamulis ornato, in margine e tomentoso fibrilloso, badio, 3-7 cm. lato; carne aquoso-flava, brunnescente; tubulis decurrentibus, flavis; poris magnis; stipite subaequale, minutissime furfuraceo, reticulato, flavo, deorsum pileo concolore sed pallidiore; sporis ochraceo-flavis, ellipsoideo-ovoideis, hyalinis sub lente,  $7-10 \times 3.5-4.5 \mu$ .

Pileus plano-convex and depressed; 3-7 cm. broad. Surface with disc adorned with small to minute, erect, terete, pointed, dark-colored fibrillose scales; perhaps tomentose or glabrescent in spots, margin tomentose to fibrillose; bay-red or dark chestnut to yellowish-brown. Flesh watery in consistency, watery-yellow, changing to chocolate-brownish; odor fungoid; taste none to mild. Tubes decurrent, with the tubes appearing like gills near the stipe, watery-yellow, unchanging, 6 mm. long; mouths concolorous, large, some 3 mm. broad, angular, compound. Stipe subequal, slightly larger at apex; very minutely furfuraceous, reticulate, often to base or only part way and then more or less rugulose, occasionally reticulate only at apex; yellow with reticulation reddish-brown, at base like pileus but paler; within watery-yellow, unchanging; 3-7 cm. long, 5-10 mm. thick. Spores ochraceous-yellow to light melleous in mass, elliptical to perhaps somewhat ovoid, hyaline,  $7-10 \times 3.5-4.5 \mu$  (mostly  $8-9 \times 4 \mu$ ). Cystidia clavate, fusiform to ventricose-rostrate, hyaline to yellow,  $35-60 \times 7-10 \mu$ .

Solitary to caespitose, under hardwoods (oaks?). Mt. Never-sink, Reading, Penn. Coll. Esther A. Dick, No. 532 in Herb. WHS.

This species has the general appearance and the spores of a *Boletinus*, although the tubes do not strikingly or generally show the radiately arranged tubes and the veins. It is apparently nearest to *B. castanellus*, but differs in the reddish-brown color, the terete scaliness, and the yellow colors of flesh, tubes and stipe.

***Boletus chrysenteroides* sp. nov.**

Pileo convexo vel plano-convexo, sicco, primo minute subtomentoso, deinde flocculoso-fibrilloso-squamuloso vel rimoso-areolato, primo fusco-umbrino vel olivaceo-brunneo, deinde pallidiore vel ochraceo-brunneo, in rimis pallido vel rubescente; carne pallido-flava, sub cutem saepe rubescente, cyanescente, odore saporeque mite; tubulis sinuato-adnatis vel dentato-decurrentibus, depressis, olivaceo-citrinis, deinde olivaceis, demum brunnescentibus, lente cyanescentibus; poris subangularibus, paululum magnis; stipite paulo curvato, saepe ventricosus, striatulus vel rugosus, apici reticulatus, e fibrilloso furfuraceo,

apici pallido-flavo, deorsum rubro, basi fusco-umbrino, intra supra pallido, deorsum purpuraceo-rubro et basi umbrino; sporis olivaceo-brunneis, e sub-fusiformibus late ellipsoideis, in longitudinenem rugosis,  $10-17 \times 5-7.5 \mu$ .

Pileus convex to plano-convex, 2-8 cm. broad. Surface dry, at first minutely subtomentose, then appressed flocculose-fibrillose-squamulose to rimose-areolate, coarsely so on disc and finer toward margin; at first deep rich brown or olivaceous-brown, later paler even to ochraceous-brown, cracks or interstices creamy to pallid or dingy, perhaps slightly pinkish or reddish. Flesh pallid yellowish or cream-colored, sometimes slightly reddish under the cuticle, changing more or less rapidly to blue, worm-holes and eaten places reddish; odor and taste pleasant and mild. Tubes adnate to sinuate-adnexed and decurrent by a tooth and hence much depressed around the stipe; at first bright lemon-yellow with more or less of a greenish tinge, at length duller and more or less olivaceous, finally dark brownish, changing slowly to bluish, 7-10 mm. long; mouths subangular, medium to large. Stipe usually more or less curved and tapering downward, perhaps ventricose; more or less striate or rugulose, perhaps somewhat reticulate at apex, furfuraceous to fibrillose; apex pallid to pale yellowish, midzone purple-red to brownish-red, and darker to brown at base; within solid, like flesh of pileus at apex, purple-red below, dingy yellowish-white to dingy brown at base, changing more or less to bluish; 3-9 cm. long, 3-15 mm. thick. Spores deep olivaceous-brown in mass, broadly elliptical to almond-shaped or subfusiform, brownish-yellow under the microscope, *longitudinally wrinkled*,  $10-17 \times 5-7.5 \mu$ , mostly  $12-14 \times 6-7 \mu$ . Cystidia clavate-ventricose to ventricose-rostrate, hyaline, abundant,  $35-70 \times 10-14 \mu$ . Mycelium white.

Under hemlocks and mixed hardwoods, presumably where oaks were once present. Province of Quebec to mountains of North Carolina and west to Michigan. Type no. 412 in Herb. WHS, from Enfield Gorge near Ithaca, N. Y.

This puzzling species was first collected by I. L. Connors at Mt. Burnet, Quebec, in 1934, but reached the writer in a badly broken condition. At the Mycological Foray at Ithaca in 1935, several specimens that in the field were called *B. chrysenteron*, were found to have the same longitudinally rugose or wrinkled, large, ellipsoid spores that were present in Connors' specimen. These specimens also resembled Peck's *B. fumosipes* in most particulars and it was then recalled that the same sort of spores had been found in Peck's types at Albany. Hence, it seemed cer-

tain that the species must be *fumosipes*, even though certain characters of this species were lacking in the newly collected plants.

When Peck's types of *B. fumosipes* at Albany were carefully studied, however, a strange situation was revealed:—some of the sporophores had broad, wrinkled-rugose spores and others had smooth and somewhat narrower spores. At first it was naturally believed that the difference in spores was probably due to a difference in maturity of the fruit bodies. The writer could not, however, convince himself that such was the case, for the following reasons:—(1) both the wrinkled-spored fruit bodies and the smooth-spored ones had cast spores in large numbers, and apparently were mature; (2) neither sort had spores of the other kind whereas one would ordinarily expect to find a mixture, if smooth ones later became wrinkled; (3) in mounts of spores from each group of fruit bodies, there can be found some hyaline spores with the colored ones, but they are the same in each mount—i.e., the hyaline ones in the mount of wrinkled spores are wrinkled like the colored (mature) ones and not smooth as one might expect if they were immature. It should be added that the smooth spores of *B. fumosipes* show a faint suggestion of lines and much time was spent in an endeavor to become convinced that these were only immature spores that would later have become wrinkled. These spores were examined at various magnifications, in different mounting media and with several kinds of light, including monochromatic lights, with the result that these vague lines seem to be entirely due to diffraction of light passing through the spore and are not wrinkles, markings or elevations on either the inside or the outside of the spore wall. The wrinkles of the truly wrinkled spores are on the outside of the wall and not on the inner surface.

*B. fumosipes* and this suggested new species are almost identical in macroscopic characters. The only differences thus far observed are as follows:—*chrysenteroides* has no bluish or greenish zone at the apex of the stipe; it has greenish-yellow tubes while *fumosipes* has greenish-white to pallid straw-colored tubes; it has wrinkled-rugose, rather deep yellow-brown spores, 6–8  $\mu$  thick while *fumosipes* has smooth, pale brownish spores 5–5.5  $\mu$  thick, except for occasional giant ones; the cystidia of *chrysenteroides* are likewise thicker than those of *fumosipes*.

Thus, with some misgivings and after much uncertainty over many months, it has been decided that on the basis of these characters, the naming of a new species is justified. It belongs in the Subtomentosi, near *chrysenteron*, if the Friesian scheme is followed.

***Boletus peralbidus* Snell & Beardslee, sp. nov.**

Pileo firmo, convexo, sicco, glabro vel subglabro, in maculis paene subtomentoso, albo, pallido-brunnescente, 3-6 cm. lato; carne alba, paululum brunnescente; tubulis adnatis, depressis, albis, fractis brunnescentibus; poris parvis, rotundis; stipite firmissimo, deorsum fastigata, aequo, minute furfuraceo, albo, paulo brunnescente; solido, intra albo; sporis e elongato-oblongis subcylindricis, sub lente hyalinis,  $7-12 \times 2.5-3 \mu$ .

Pileus firm, convex, 3-6 cm. broad. Surface dry, glabrous or nearly so, almost subtomentose in spots, white, becoming pale brownish or dingy whitish with age. Flesh white, dingy brownish when cut, up to 10-15 mm. thick. Tubes adnate, deeply and narrowly depressed, white becoming dingy-brownish when cut; mouths small, rotund. Stipe unusually firm, mostly tapering downward, even, minutely furfuraceous, white, the mealiness becoming ochraceous-brownish, staining brownish where wounded; within solid, white; 3-4 cm. long, 10-14 cm. thick. Spores probably pale ochraceous in mass, subcylindrical to elongate-oblong-elliptical, hyaline,  $7-12 \times 2.5-3 \mu$ , mostly  $8-10 \times 2.5 \mu$ . Cystidia abundant, glutinous and often incrustated with spores, fusiform, dingy yellow or yellowish-brown with hyaline apex,  $35-50 \times 7-10 \mu$ .

Altamonte Springs, Florida. Coll. H. C. Beardslee. No. 529 in Herb. WHS; 35,167 in Herb. HCB.

There are only a few really white species of *Boletus*. In a few cases, occasional specimens of certain species are found bleached by the rain. Some of these are in the group with viscid pileus. Other than these Viscipelles, there are only four white species. *B. frustulosus* is southern, and distinctly frustulose. *B. subalbellus* has a hollow stipe and rather broadly elliptical spores. *B. albellus* and *B. niveus*, of the *scaber* group, have large fusiform spores, more or less colored. *B. peralbidus* is distinguished, therefore, from most species by its whiteness throughout, and from the white forms by its general smoothness, its solid stipe and its narrowly cylindrical spores. It is placed tentatively in the Versipelles in spite of the aberrant spores.

**Boletus scabroides** Kauff. sp. nov.

Pileo plano-convexo, recente paululum viscido, aequo, glabro, in maculis minute rimoso, isabellino vel ochraceo-brunneo, 6-10 cm. lato; carne molle, e pallida flavo-albida, paululum cyanescente, odore saporeque mite; tubulis adnatis, depressis, flavovirentibus, vix cyanescentibus; stipite e substriato aequo, subreticulato, minute furfuraceo vel minute scabro, apici citrino, deorsum pallido-brunneo vel flavo rubrotincto, rubro-furfuraceo, intra flavo, lente cyanescente; sporis sub lente pallido-flavovirentibus, subfusiformibus,  $11-15 \times 2.5-5 \mu$ .

Pileus convex to plane, 6-10 cm. broad. Surface slightly viscid when fresh, even, glabrous, minutely rimose in spots; pale tan, ochraceous cinnamon, or brown ochraceous. Flesh soft, whitish to pale yellowish, changing slightly to bluish or not at all changing; taste and odor mild, except surface bitter. Tubes adnate, becoming depressed and half adnate, as long as flesh is thick; greenish-yellow, becoming sordid greenish-yellow in age, scarcely changing to blue; mouths angular, some more or less compound, 1-2 mm. Stipe even to somewhat striate, tending towards reticulate, minutely furfuraceous to scurfy or minutely scabrous except at apex; citron yellow at apex and chrome yellow at base, in between pallid tinged brownish or perhaps mostly yellow tinged reddish, with the scurf sometimes reddish; within yellow, changing very slowly to pale blue; 5-9 cm. long, 6-20 mm. thick. Spores very pale greenish-yellow under the microscope (in old specimens), subfusiform,  $11-15 \times 3.5-5 \mu$ , some to  $18 \mu$ , mostly  $12-14 \times 4-4.5 \mu$ .

Solitary, in hemlock or spruce woods or swamps. Ann Arbor, Michigan. Coll. C. H. Kauffman. No. 562 in Mich. Herb.; 451 in Herb. WHS.

This species seems to belong in the Subpruinosi, in the absence of stuffed tubes. It is distinguished by the pale tan to brownish-ochraceous colors of the pileus, stipe yellow at apex and base, and scurf usually reddish. It is nearest to *B. glabellus*, from which it differs in the stipe characters, and the glabrous pileus.

**Boletus plumbeotinctus** Kauff. sp. nov.

Pileo late convexo, obtuso, viscido, demum ruguloso, primo "clay color," mox "dark olive gray," 7-8 cm. lato; carne firma, crassa, alba, odore saporeque mite; tubulis adnatis, subdepressis, paucis decurrentibus, inaequalibus, "mustard yellow"; poris angularibus; stipite breve, subaequale, leve, glabro, albo, apici pallido-flavo, solido intra albo; sporis anguste ellipsoideis vel subcylindricis, sub lente e pallido-flavis hyalinis,  $7-9 \times 2.5 \mu$ .

Pileus broadly convex, obtuse, edge extending beyond tubes, 7-8 cm. broad. Surface *viscid*, even, becoming rugulose from the drying gluten, at first clay color, soon dark olive-gray (R). Flesh firm, thick compact, white, unchanging; taste and odor mild. Tubes adnate, subdepressed, few decurrent, uneven, with projecting tongues, mustard-yellow, 5-7 mm. long; unchanging; mouths angular, 2-3 a mm. concolorous. Stipe short, subequal, even glabrous, white, pale yellowish at apex; within solid, white; 3.5 cm. long, 15-20 mm. thick. Spores narrowly elliptical or sub-cylindric, hyaline to perhaps very pale yellowish,  $7-9 \times 2.5 \mu$ , mostly  $7-8 \mu$  long.

Under spruce and pine. Leal, Colorado. Coll. C. H. Kauffman. No. 560 in Mich. Herb.; 485 in Herb. WHS.

This species belongs in the *Viscipelles* and is distinguished by colors of the pileus (clay color to dark olive gray), stipe yellow at apex and white below, and the small spores.

***Boletus rubescentipes* Kauff. sp. nov.**

Pileo convexo, sicco, leve, glabro vel subpruinoso, vix subtomentoso, primo "dingy buff-whitish," deinde "dingy avellaneous," 5-10 cm. lato; carne alba, fracta subrubescente, sapore mite; tubulis adnato-depressis, vix decurrentibus, primo pallido, deinde "deep colonial buff," demum "ecru olive"; poris angularibus; stipite fortasse deorsum fastigato, leve, glabro, concolore vel pallidiore, intra albo, subrubescente; sporis brunneo-olivaceis, subfusiformibus, sub lente pallido-olivaceis vel flavovirentibus,  $8-12 \times 4-5.3 \mu$ .

Pileus convex, 5-10 cm. broad. Surface dry, even, glabrous or subpruinose, hardly subtomentose, at most only very obscurely and very minutely so, at first dingy buff-whitish, then dingy avellaneous or pale brownish and mottled with small darker drop-like spots. Flesh white, becoming faintly dingy pinkish when cut, taste mild, odor none. Tubes adnate-depressed, hardly decurrent, at first pallid, slowly deep colonial buff, finally ecru-olive from spores, 5-9 mm. long; mouths angular, often subsinuate by coalescence of two, about 2 a mm. Stipe perhaps tapering downward, curved at base, even, glabrous, concolorous or a little paler in color, changing to more or less pinkish when rubbed; within white, turning dingy pinkish; 5-7 cm. long, 7-15 mm. thick. Spores light brownish-olive to brownish-olive in mass, subfusiform and narrowed on one side at distal end, pale olivaceous to slightly greenish-yellow,  $8-12 \times 4-5.3 \mu$ , mostly  $9-11 \times 4-4.5 \mu$ . Cystidia narrow, hyaline fusiform or obtuse,  $50-70 \times 6-10 \mu$ . Subhymenial bodies, deep yellow, obtuse,  $25-30 \times 12-15 \mu$ .

Mt. Gretna, Penn. Coll. C. H. Kauffman. No. 570 in Mich. Herb.; 487 in Herb. WHS.

This belongs in the Subpruinosi and is distinguished by the buffish colors of the pileus, and the flesh of pileus and stipe turning pinkish to reddish.

**Boletus subclavatosporus** sp. nov.

Pileo convexo vel plano-convexo, sicco, e subpruinoso glabro, rare minute subtomentoso, in maculis minute rimoso-areolato, "dingy warm buff," 5-10 cm. lato; carne sordido-alba, cyanescente, decolorante, sapore felleo; tubulis e subdecurrentibus adnatis, subdepressis, primo albis vel pallido-stramineis, demum pallido-flavo-olivaceis, fractis brunneo-olivaceis; poris rotundis vel subangularibus; stipite gracile, subaequale, leve, glabro vel obscure furfuraceo-punctato, e tubulis subreticulato, subconcolore, intra supra sordido-albo, deorsum sordido-rubro; sporis late clavatis vel subclavatis, paucis subcylindricis, pallido-olivaceis sub lente,  $11-14 \times 4-4.5 \mu$ .

Pileus convex to plano-convex, 5-10 cm. broad. Surface dry, glabrous to subpruinose, rarely minutely and obscurely subtomentose, in places minutely rimose-areolate, dingy warm buff. Flesh dingy white, *turning King's blue when cut*, sometimes deeper blue, fading again, 15 mm. thick; taste *bitter*. Tubes convex, adnate to slightly subdecurrent, more or less depressed, at first white or very pale yellowish-white, becoming at maturity light yellowish-olive, brownish-olive where bruised, 5-9 mm. long; mouths rotund to subangular, 2-3 a mm. when young, 1-2 when older. Stipe medium slender, equal or nearly so, even, glabrous or obscurely scurfy-dotted except at apex where it is slightly reticulate from decurrent walls of tubes, slightly paler than pileus; within dingy white above, dingy reddish in lower half, unchanging; 6-12 cm. long, 8-15 mm. thick. Spores probably brownish-olivaceous in mass, broadly clavate or subclavate, with one end narrowed, few somewhat narrowly diamond-shaped, few subcylindric, pale olivaceous or slightly olivaceous-yellow tinged,  $11-14 \times 4-5 \mu$ . Cystidia abundant, often clustered, fusiform, hyaline,  $40-60 \times 4-8 \mu$ .

Subcespitose or gregarious along river. Hot Springs, North Carolina. Coll. C. H. Kauffman. No. 556 in Mich. Herb.; 488 in Herb. WHS.

This belongs in the Subpruinosi and is distinguished by the buff color of the pileus, the bitter taste of the flesh and its change to bright blue, the white or whitish color of the tubes when young, the reddish color of the stipe within downwards, and the subclavate spores.

## ERRORS CORRECTED

In "Notes. II" (pp. 220-231) <sup>3</sup> it was argued that *B. isabelinus* Peck is probably not the same as *B. Ananas* M. A. Curtis, as maintained by Murrill, but more likely the same as *B. subalbellus* Murrill, from the same locality. Further study of the specimens available, however, has convinced the writer that he was wrong and that Murrill was right.

In "Notes. I" (pp. 335-336) <sup>4</sup> it was stated that in all probability, *B. sordidus* Frost is the same as *B. porphyrosporus* Fries. This statement is likewise an error, because of the difference in the spores. It is much more likely that *B. sordidus* and *B. fumosipes* Peck are the same plant, but this remains to be demonstrated.

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<sup>3</sup> Snell, Walter H. Notes on Boletes. II. Mycologia 25: 221-232. 1933.

<sup>4</sup> Snell, Walter H. Notes on Boletes. I. Mycologia 24: 334-341. 1 fig. 1932.



# THE LIFE HISTORIES OF BOTRYOSPHERIA MELANOPS AND MASSARIA PLATANI

C. L. SHEAR AND ROSS W. DAVIDSON

(WITH 5 FIGURES)

Among the specimens sent into the Washington laboratory of the Division of Forest Pathology for identification, there are occasional fungi of more than ordinary interest, either because of their scarcity or because, in the course of the work incidental to their identification, some new information is secured regarding them. These criteria apply to specimens of the two fungi with which this paper is concerned.

## BOTRYOSPHERIA MELANOPS (Tul.) Wint.

*Botryosphaeria melanops* was collected on red oak, *Quercus borealis*, in Meshomasic State Forest, Connecticut, September 27, 1935, by Bailey Sleeth (F.P. No. 67,970). This fungus is apparently not common in Europe and has not been reported previously in America, according to the Farlow Index, which was very kindly examined by G. D. Darker. Moreover, until now its life history has been based entirely on the association of the different spore forms on the host. The material sent in was abundant. The ascospores measured  $31-48 \times 14-21 \mu$ , mostly  $34-36 \times 16-18 \mu$ ; macropycnospores  $41-53 \times 9-11 \mu$ , mostly  $47-50 \times 10-10.5 \mu$ .

Tulasne (4) first described and illustrated this fungus completely in 1863. He found ascospores and macro- and micropycnospores all in the same stroma, which would seem to be fairly reliable proof of the genetic relation of the three spore forms; yet confirmation by pure cultures, even in such cases, seems desirable. Tulasne stated that he found the fungus common on cut branches of oak in the vicinity of Paris. The only other reference he made to specimens was to Fries, Scler. Suec. Exs. No. 143, 1821. On page 298 l. c. he stated that the specimen of this number he examined had only macropycnospores,

which are especially characteristic in this species. He also said that Cesati and DeNotaris had referred the same specimen to *Ascoxyta Quercus* Lib., Crypt. Ard. No. 46, 1863. We have not had an opportunity to examine Libert's specimen. A specimen of this same number of Fries exsiccatae which we have examined also shows typical macropycnosporos of *B. melanops*.

Only two somewhat doubtful European specimens of this species that we have seen show ascospores. No. 1547, C. Roumeguere, Fung. Gall. Exs. collected in Malmedy, Belgium, by Libert and labelled *B. advena* (C. & D.) on oak, has ascospores in the specimen in The New York Botanical Garden Herbarium set. They are  $30-33 \times 12-15 \mu$ , and have the typical shape of the spore in this species. No pycnidia were found associated with them. These spores it should be noted are somewhat smaller than the average, as given by Tulasne (4), Schroeter (2), and Winter (6), and also as found in the specimen from Connecticut. The other specimen was distributed by Petrak, No. 107 Fl. Boh. & Morav. Exs., on *Quercus Robur*, Weisskirchen, 1912, as *Botryosphaeria melanops* (Tul.) Wint. The specimen of this number in the mycological collections of the Bureau of Plant Industry shows one piece of oak bark having good *Botryosphaeria* stromata with asci and ascospores. The spores are somewhat rhomboid, become brown when old and measure  $27-36 \times 12-15 \mu$ , mostly  $30 \times 14 \mu$ . On this same piece of bark, however, closely associated with the perithecial stromata are others showing macropycnosporos of *Dothiorella* very variable in shape, mostly  $10-12 \times 5-6 \mu$ . Sometimes when mature they are longer and somewhat allantoid,  $15 \times 18 \times 5-6 \mu$ . These, it will be noted, are quite different from the macropycnosporos of *B. melanops*. All the other four or five pieces of this specimen show the same *Dothiorella* stromata and spores, but no ascospores. If these pycnosporos belong to the closely associated *Botryosphaeria*, it must be a different species from the *B. melanops* (Tul.), which, as already noted, has macrospores four or more times as long. This case, as we have observed before in species of *Botryosphaeria* and *Physalospora*, shows the difficulty of identifying the species from ascospores only; as species having similar ascospores sometimes have quite different macropycnosporos. Hence, neither of the two asco-

genous specimens just mentioned can be said with certainty to be true *B. melanops*. In the present state of our knowledge of this and related species, the most dependable character for identifying this species is that of the macropycnospores, which far exceed in size any others at present known. The following specimens which we have examined show macropycnospores of this species:

No. 2363 Fuckel, Fun. Rhen. issued as *Melanops Tulasnei* Nitschke, which shows only macropycnospores  $40-45 \times 8-10 \mu$ .

No. 1896 Krieger, Fun. Sax. Exs. on *Quercus*, Saxony, May, 1886, issued as *Dothiorella advena* Sacc. shows only macropycnospores  $43-52 \times 8.5-10 \mu$  which become yellowish brown when old and evidently belong to *B. melanops* (Tul.). Of course, there is the possibility that there is another species of *Botryosphaeria* having similar macropycnospores. Rabenhorst, Fun. Europ. No. 1034 labelled *Dothidea melanops* forma *pycnidifera* on oak shows only micropycnospores according to the specimen of this number in the mycological collections of the Bureau of Plant Industry and it is therefore uncertain whether they belong to this species or to one of the others found on this host.

It would seem, judging from the scarcity of specimens in the larger herbaria, that the species is not common in Europe. However, Schroeter (2) reported specimens from four or five localities, and Traverso (5) gave three localities in Italy. Our lack of knowledge of the distribution of this and related species of *Botryosphaeria* and *Physalospora* is due in part to the ease with which the various species are confused or overlooked in the field, as there are at least two or three species of *Physalospora* and an equal number of *Botryosphaeria* occurring on oak with their pycnidial forms, whose general macroscopic appearance is so similar as to make it difficult if not impossible to recognize them with certainty without microscopic examination. Many more collections and more study of this group are needed in order to determine the number and distribution of the species in this country as well as in Europe.

The synonymy so far as we know it at present is as follows:

## ASCOGENOUS FORM

*Dothidea melanops* Tul. Ann. Sci. Nat. IV, 5: 116, 1856.

*Melanops Tulasnei* Nitschke in Fuckel. Symb. Myc. 225. 1869.

*Botryosphaeria advena* Sacc. Michelia 1: 42, 1877, not Ces. and DeNot. 1863 sec. Wint.

*Botryosphaeria melanops* (Tul.) Wint.; Rabenh. Krypt.-Fl. 1<sup>2</sup>: 800. 1887.

## PYCNIDIAL FORM

*Sphaeria quercina* Fries as represented in Scler. Suec. Exs. No. 143, not Pers.

*Dothiorella advena* Sacc. Michelia 2: 620, 1882.

*Fusicoccum testudo* v. Höhn. Ann. Myc. 1: 399. 1903. The *Dothiorella* stage.

## LIFE HISTORY

Single-ascospore cultures made from the specimen from Connecticut by Mrs. A. F. Kempton, Bureau of Plant Industry, and grown on corn meal in flasks after seven or eight weeks in a cool greenhouse produced scattered subspherical pycnidia 1 to 3 mm. in diameter, containing abundant macropycnosporos of *Dothiorella advena* Sacc., averaging about  $52 \times 10 \mu$ . They were more uniform in size, but otherwise identical with those found associated with the ascogenous form on the specimens. No micro-pycnosporos were found on the specimen or in the cultures.

An outstanding characteristic of *Botryosphaeria melanops* was its slowness of growth in culture as compared with other fungi of this group, or indeed with many fungi which the writers have studied. *B. melanops* does not seem to be particularly limited, however, in its temperature range or especially restricted as to culture media; it merely grew very slowly on all the media tried. For example, at 20° C. on corn-meal agar plates its average growth was 0.7 mm. per day as compared to 3.5 mm. per day for *B. Ribis*.

Ascospores of *B. melanops* required two or three days to germinate. Under the environmental conditions and on the various culture media which have been found favorable for fungi of this group, six weeks was required for the production of pycnosporos. Further development was also very slow. A 3-months-old culture on corn-meal flasks in a cool greenhouse still had a considerable number of pycnidial stromata filled with

young normal-appearing macropycnosporos. In the culture of *B. Ribis* of the same age the pycnidia would usually have been empty and the pycnosporos long since germinated.

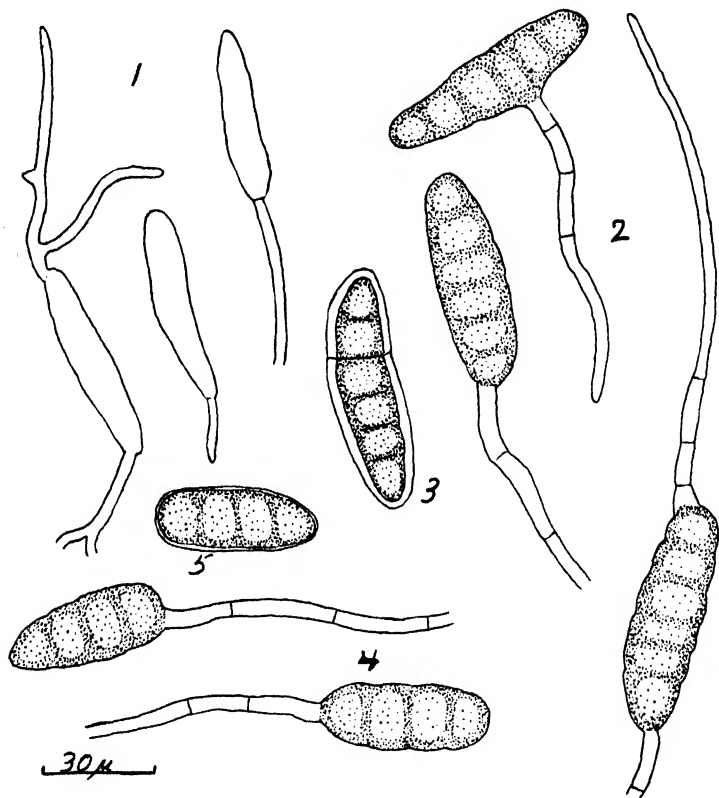


FIG. 1-5. 1, germinating macropycnosporos of *Botryosphaeria melanops*; 2, germinating ascospores of *Massaria Platani* with a normal ascospore shown in figure 3; 4, germinating pycnosporos of *Massaria Platani*; 5, a normal pycnosporos of this same fungus.

Macropycnosporos germinated readily on corn-meal agar (FIG. 1) and produced cultures which are similar in every respect to those obtained from ascospores.

#### MASSARIA PLATANI Ces.

Specimens of *Massaria Platani* were collected on a sycamore tree in Washington, D. C., December 18, 1934, by Bowen Crandall (F.P. No. 59149). The ascogenous stage was fruiting

in abundance around a branch stub. A diffuse type of canker was forming along the living stem with the pycnidial (*Hendersonia*) stage fruiting in abundance on the outer edges. A slight brown discoloration extended down into the dead and dying sapwood underneath the canker.

This is a common species in this vicinity, but its life history has been merely assumed from the association of the two spore forms, and as this collection contained an abundance of both stages in good fruiting condition it was thought advisable to obtain cultures from both ascospores and pycnosporos. The ascospores were mostly 6-celled and measured  $58-68 \times 14-16 \mu$ . The pycnosporos were 4-celled and measured  $44-52 \times 17-20 \mu$ . These agree well with measurements given in the descriptions of *Massaria Platani* Ces. and *Hendersonia Desmazieri* Mont., and with herbarium specimens of them.

An examination of part of the type specimen of (3) *Stilbospora quadrisepitata* Schw. found in Michener's herbarium shows that it is the same as *Hendersonia Desmazieri* Mont. Berlese (1) stated that *Massaria atroinquinans* Berk. & Curt. according to the original specimen which he examined is the same as Cesati's species. A Curtis specimen of this which we have examined has all the macroscopic characters of this species, but it is old and no ascospores could be found.

The synonymy of the species is as follows:

#### ASCOGENOUS FORM

*Massaria Platani* Ces. in Rab. Fun. Europ. Exs. Ed. 2, no. 323. 1861.

*Sphaeria Pupula* Fries (p.p.) Syst. Myc. 2: 484. 1823 sec. Berl.

*Massaria atroinquinans* Berk. & Curt. Grevillea 4: 156. 1876.

?*Massaria semitecta* Berk. & Curt. Grevillea 4: 147. 1876. sec. Berl.

#### PYCNIDIAL FORM

*Stilbospora quadrisepitata* Schw. Trans. Am. Phil. Soc. II. 4: 299. 1832.

*Hendersonia Desmazieri* Mont. Ann. Sci. Nat. Bot. III. 12: 310. 1849.

*Steganosporium Platani* Preuss, Fun. Hoyersw. Linn. **26**: 723. 1853.

*Hendersonia Platani* Peck, Rep. Bot. N. Y. St. Mus. **25**: 86. 1873.

#### LIFE HISTORY

Both the ascospores and pycnospores germinated readily on corn-meal agar in 24 hours (FIGS. 2, 4). Single-ascospore and single-pycnospore cultures grew very slowly on malt-extract agar and appeared identical in every respect.

After 5 to 7 weeks growth on malt agar at room temperature of about 24° C. the ascospore cultures produced pycnidia containing pycnospores. These pycnospores were more irregular in shape and size than those produced in nature but in other respects were similar. Pycnospores produced by the pycnospore cultures were indistinguishable from those produced by ascospore cultures.

This fungus is somewhat similar to *Botryosphaeria melanops* in cultural characteristics as it grows very slowly on agar media and has the same color and general appearance of the mycelium. On malt agar at ordinary room temperature it grows even more slowly than *B. melanops*, but on corn meal in flasks at the same temperature it grows at an average rate of 1.8 mm. per day, which is about twice that of *B. melanops* under the same conditions.

DIVISIONS OF MYCOLOGY AND DISEASE SURVEY AND FOREST  
PATHOLOGY, BUREAU OF PLANT INDUSTRY

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# NEW AND UNUSUAL DISCOMYCETES OF WESTERN WASHINGTON

LEON C. SNYDER

(WITH 3 FIGURES)

While preparing his doctor's thesis, "The Operculate Discomycetes of Western Washington," the author collected and identified 72 species of the above group. Many of these are common and widespread forms, others are new or rare and should therefore be of special interest.

## 1. ASCOBOLUS CARBONARIUS Karst.

Collected only once on charred leaves and twigs where a brush pile had been burned. Redmond, March 10, 1934.

This species is of interest because of its habitat and beautifully warted, brown spores.

## 2. ASCOBOLUS VIRIDULUS Phill. & Plow.

Collected on the dung of a wild animal, possibly a squirrel. Edmonds, Feb. 10, 1934.

This species has formerly been reported only on the dung of dogs and birds. The apothecia examined were larger than those usually described, reaching a diameter of 3-4 mm. The size of the spores and spore sculpturing were however the same.

## 3. HELVELLA CRISPA (Scop.) Fries.

On soil in open woods near Seattle from October to December.

This species has been collected in close association with *H. lacunosa* and all gradations between snowy-white and almost black have been found. A more careful study is needed to determine whether our western form is a distinct species or only a variety of *H. lacunosa*.

## 4. HUMARINA CONVEXULA (Pers. ex Fries) Seaver.

Collected only once on burnt ground among moss near Bothell, Feb. 23, 1935.



This rare and beautiful species is characterized by its small size, convex hymenium, and bright orange color.

5. **Humarina macrocystis** (Sacc.) comb. nov.

*Peziza macrocystis* Cooke, Mycographia 36. 1875.

Apothecia scattered, shallow cup-shaped to discoid, reaching a diameter of 5–8 mm., externally dull-orange, attached by a broad base with flexuous mycelial hairs; excipulum composed of large thin-walled cells up to 30 microns in diameter; hymenium bright-orange, plane; asci cylindrical, with a narrowed base, 225–250  $\times$  13–14 microns, 8-spored; spores 1-seriate, narrow-ellipsoid, smooth, 7–10  $\times$  18–21 microns, containing two conspicuous oil-drops; paraphyses enlarged above to 6–8 microns, containing orange granules.

On burnt ground among moss. Seattle, Feb. 3, 1935.

This species has not been reported before for the United States. It agrees well with the description in "British Fungus Flora" by Masee.

6. **Lamprospora fulgens** (Pers.) comb. nov.

(*Pseudoplectania fulgens* (Pers.) Fuckel, Symb. Myc. 324. 1869.)

On soil in coniferous woods. Lake Keechelus, May 5, 1934.

This species is usually placed in the genus *Pseudoplectania*. It lacks the black color, cartilaginous texture and well developed hairs of the other two species of the genus. The poorly developed hairs do not exclude it from the genus *Lamprospora* as the outer cells of many of the *Lamprospora* species run out into clavate outgrowths.

7. **Lamprospora pyrophila** sp. nov.

Apothecia scattered to gregarious, sessile, at first globose, becoming expanded and discoid, with an even margin, reaching a diameter of 3–5 mm., externally smooth, salmon-pink; excipulum consisting of interwoven, swollen-celled hyphae; hymenium plane, smooth, salmon-pink; asci cylindrical, 150–200  $\times$  10–12 microns, 8-spored; spores 1-seriate, globose, 7–9 microns in diameter, smooth; paraphyses filiform, hooked at their apices, often forked.

On burnt ground. Canyon Park, Bothell, Feb. 25, 1934;

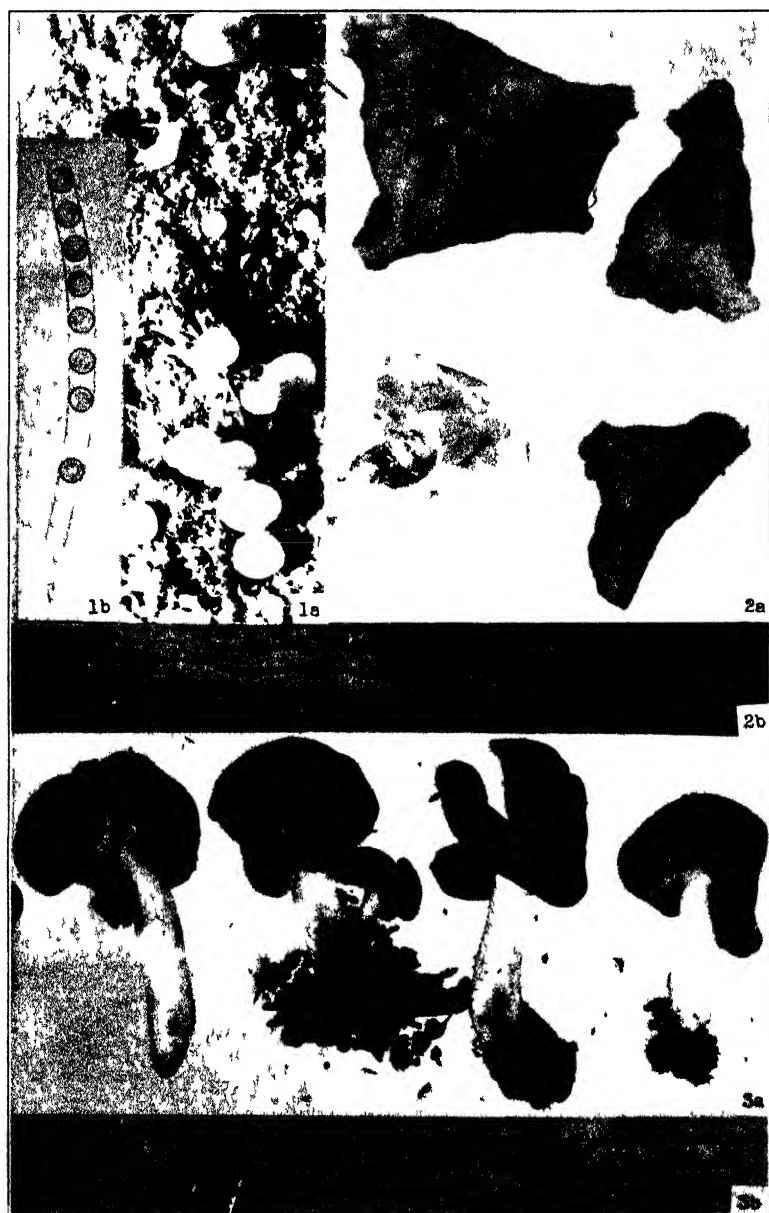


FIG. 1a, habit sketch of *Lamprospora pyrophila*,  $\times 2$ ; 1b, ascus of *L. pyrophila*,  $\times 333$ ; 2a, *Paxina recurvum*,  $\times \frac{1}{3}$ ; 2b, ascus of *P. recurvum*,  $\times 266$ ; 3a, *Paxina compressa*,  $\times \frac{2}{3}$ ; 3b, ascus of *P. compressa*,  $\times 200$ .

Redmond, March 10, 1934; Spanaway Lake, Tacoma, March 2, 1935.

This is a very beautiful and common species in the spring, being found where brush has recently been burned. It differs from *L. carbonaria* in its smaller spores which lack the prominent oil drop.

Apothecia sparsa aut gregaria, sessilia, primum subglobosa, disciformia eventa, margine integra, 3-5 mm. in latitudine, externiter levia, "salmon-pink"; excipulum de hyphis intermixtis cellarum tumidarum; hymenium planum, leve, "salmon-pink"; asci cylindracei, 150-200  $\times$  10-12 microns, octospori; sporidia monosticha, globosa, 7-9 microns in latitudine, levia; paraphyses filiformes, apicibus suis incurvatae, saepe divisae.

In carbonicola. In venta Febuario et Marte per Washington ad septentriones, Amer. bor.

#### 8. *PATELLA ABUNDANS* (Karst.) Seaver.

On coke and burnt ground. Canyon Park, Bothell, Feb. 25, 1934.

Our western form is much larger than the Eastern or European species, frequently reaching a size of 1 cm. The color, spore characters, and hairs agree well with the description given by Seaver.

#### 9. *Paxina compressa* sp. nov.

Apothecia scattered, stipitate, laterally compressed, becoming irregularly lobed, reaching a diameter of 3-4 cm., externally grayish white, covered with fascicles of loosely interwoven hairs; hairs consisting of swollen cells, reaching a diameter of 20-30 microns; stalk white, 4-5 cm. long, up to 1 cm. wide at the base and 5-8 mm. wide where the stalk joins the apothecium, very slightly lacunose; hymenium grayish brown, wavy, smooth; asci cylindrical, 350-400  $\times$  14-16 microns; spores ellipsoid, containing one very large oil-drop and numerous small ones, 13-19  $\times$  23-25 microns, smooth; paraphyses filiform, slightly enlarged above to 3-6 microns.

On the ground in deep woods. Easton, May 5, 1934.

This is a border-line species between *Paxina* and *Helvella*. The white stalk and laterally compressed apothecium are the distinguishing characters.

Apothecia sparsa, stipitata, lateraliter compressa, eventa inique lobula, 3-4 cm. in latitudine, externiter "grayish white," tomentosa; stipes albus,

4-5 cm. in longitude, 5-10 mm. in latitudine, lacunosissimus; hymenium "grayish brown," iniquum, leve; asci cylindracei,  $350-400 \times 14-16$  microns; sporidia ellipsoidea,  $13-19 \times 23-25$  microns, habenta unam guttulam maximam et multas parvas; paraphyses filiformes, sursum clavatae.

In terro in silvis densis. In venta Maia, Easton, Washington, Amer. bor

#### 10. *Paxina recurvum* sp. nov.

Apothecia with short thick stalks, widespreading, reaching a diameter of 10 or more cm., with a strongly recurved margin on three or more sides giving the top an angular appearance, externally dull-white, finely tomentose; stalk short and thick, 2-3 cm. long and up to 3 cm. wide where it joins the apothecium, whitish, slightly lacunose, tomentose; excipulum prosenchymatous, consisting of interwoven, swollen-celled hyphae; hymenium convex, smooth to wavy, light brown; asci cylindrical, with a narrow twisted base,  $325-350 \times 13-15$  microns, 8-spored; spores broad-ellipsoid,  $14-16 \times 9-11$  microns, with two large oil-drops, very minutely roughened by small warts; paraphyses up to 8 microns at the apex, brown, sparingly septate.

On ground in dense woods. Snoqualmie Pass, April 14, 1934; Lake Keechelus, May 5, 1934.

This species is unlike any of the other *Paxinas* because of its repand habit but possesses a stalk and a tomentose exterior.

Apothecia stipitata, expansa late, 10 cm. in latitudine, margine recurva in lateribus tribus aut pluribus, externiter "dull-white," tomentosa; stipes 2-3 cm. in longitude et ad 3 cm. in latitudine, albus, lacunosissimus, tomentosus; excipulum prosenchymatum, de hyphis intermixtis cellarum tumidarum; hymenium convexum, leve aut undulatum, "light-brown"; asci cylindracei, pede angusto torto,  $325-350 \times 13-15$  microns, octospori; sporidia late ellipsoidea,  $14-16 \times 9-11$  microns, duabus magnis guttulis, asperula; paraphyses filiformes, sursum clavatae.

In terra in silvis densis. In venta Avril, Snoqualmie Pass, Washington, Amer. bor.

#### 11. *PEZIZA BUFONIA* Pers. ex Fries.

Apothecia sessile, shallow cup-shaped, with upturned, even or notched margin, reaching a diameter of 5 cm., externally brown, warted; excipulum consisting of large swollen cells interspersed between swollen-celled hyphae, outer cells pseudoparenchymatous, grouped to form wart-like pustules; hymenium concave to plane, brown; asci  $350-400 \times 20-24$  microns, cylindrical, 8-spored; spores 1-seriate, ellipsoid, smooth,  $10-12 \times 18-20$  microns; paraphyses slender, slightly enlarged above to 8 microns.

On rich soil and garbage dumps. Common near Seattle in March.

This is the first report for this species in the United States.

12. *PITHYA VULGARIS* Fuckel.

On recently killed branches of fir above snow-line. Snoqualmie Pass, March 11, 1934.

This uncommon species is characterized by its spongy texture, spherical spores and habitat.

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# PERFECT STAGE OF THE SWEET ORANGE FRUIT SCAB FUNGUS <sup>1</sup>

A. A. BITANCOURT AND ANNA E. JENKINS

(WITH 2 FIGURES)

The causal fungus of sweet orange fruit scab was identified and described as *Sphaceloma Fawcetti viscosa* Jenkins in 1933 (3) on the basis of the fungus as found on Bahia Navel (*Citrus sinensis* Osb.) from Limeira and Sorocaba, leading citrus centers in São Paulo, Brazil. The subsequent search for the perfect stage of this fungus has been rewarded by its discovery, also on the Bahia



FIG. 1. Lesions of sweet orange fruit scab on sweet orange from the State of São Paulo.  $\times 1$ .

Navel from São Paulo. This myriangiaceous ascomycete, an *Elsinoe*, was found on only one of a large number of severely

<sup>1</sup> Contribution from the Instituto Biologico de São Paulo, and the Bureau of Plant Industry, Washington, D. C.



FIG. 2. *Elsinoe australis*. Lesions in figure 1, *a*, enlarged to show ascomata.  $\times 20$ . B, an ascoma (*a*) protruding through conidial layer (*b*). C, *a*, clearer view of asci. D, another ascoma, showing 3-septate ascospore (*a*); *b*, conidial layer. B-D,  $\times 600$ .

diseased fresh ripe Navels received on July 4, 1936 (FIG. 1). Ascomata were present on a limited number of lesions and were abundant only on those shown in figure 2, *a*.

On lesions, blackened by the conidial layer of the imperfect stage, the ascomata were recognized by the fact that some of the pustules as examined by the binocular were black on the periphery only, while the center was buff. These pale areas (FIG. 2, A, *a*) were ascomata, which had formed as an ectostroma within the conidial layer. The ascomata were in all stages of development, although immature for the most part. They were globose or nearly so, with well developed pseudoparenchyma, in contrast to the more scanty flattened ascomata of *Elsinoe Fawcetti* Bitancourt and Jenkins (*Sphaceloma Fawcetti* Jenkins) (1). The ascospores were also larger and more variable than those observed for *E. Fawcetti*.

It is believed that these differences, together with those of the conidial stages, already shown (2, 3), warrant the separation of the variety *viscosa* from *E. Fawcetti* as a distinct species, as has been contemplated from the first. The distinguishing varietal name *viscosa* was chosen because of the extremely viscous nature of the cultural growth, although viscosity is now known to be only one of the numerous variations in cultures of this fungus (3). In treating the new *Elsinoe* as a species, the name *australis* is suggested for the perfect stage, as well as for the conidial stage when referred to as of the genus *Sphaceloma*, i.e., *S. australis*. The following diagnosis of the ascomycete is given:

***Elsinoe australis* sp. nov.**

Ascomata globose, sometimes flattened or irregular, occasionally confluent, 40–120  $\mu$  in diam., buff, embedded in the tissues of the perfect stage, erumpent, consisting of a hyaline or slightly yellowish pseudoparenchyma devoid of a well defined epithecium; asci often distributed in the upper part of the ascoma, globose to obclavate, inner wall thickened apically, 15–27  $\times$  13–21  $\mu$ ; ascospores hyaline, variable, straight or more or less curved, 2–4 celled, often markedly constricted not only at median septum, but also at the other two, sometimes with a longitudinal septum in the upper middle cell, which is frequently slightly larger than the other cells, 12–20  $\times$  4–8  $\mu$ . Conidial stage, *Sphaceloma australis* Bitancourt and Jenkins.



Ascomatibus saepe globosis, 40–100  $\mu$  in diam., pallide flavidis to ochraceis, in textura fructificationis conidicae immersis, dein erumpentibus; ascis 15–27  $\times$  13–21  $\mu$ ; ascosporis 2–4-cellulatis, 12–20  $\times$  4–8  $\mu$ .

On *Citrus sinensis* Osb. var. Bahia Navel, causing lesions of the disease known as sweet orange fruit scab, São Paulo, probably Torrinha, received July 4, 1936. In Herb. Phytopath. Instituto Biologico de São Paulo, Brazil, No. 2256.

Similar to *Elsinoe Fawcetti*, but with different host adaptations; separable from it in several morphological characters, including well developed globose ascomata, longer ascospores, apparent absence of a well developed epithecium, and persistent conidial stage not characterized by the *Cladosporium*-like development of *E. Fawcetti*, which is more evanescent.

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## NOTES AND BRIEF ARTICLES

Species of the higher fungi more and more are being distinguished on the basis of such details of microscopic structure as the make-up of the cuticle, etc. For example, *Pluteus coccineus* has been recognized as distinct from *P. leoninus* not only in color, but also in having a cuticle made up of globulose cells instead of interlaced hyphae. Similarly, the boletes of the group *Versipelles* (*scaber-versipellis* group) are slowly being disentangled partly on this basis. In this complex, it is important not only to make careful distinctions between those species which have a glabrous surface and those which are fibrillose or tomentose, but also it has become apparent that the fundamental nature of the glabrosity must be used, as for example in the white forms variously called *B. niveus*, *B. albellus* and *B. holopus*, etc. In these species (or varieties, as some of them have been called), surfaces that to the naked eye or a hand lens appear truly glabrous, smooth and shiny, will be found when examined microscopically to vary as above noted.

In this connection it seems to be important to have proper terms not only to describe the condition but also to emphasize the difference. Therefore, the following terms are proposed: GLOBULOSE-GLABROUS, referring to a cuticle which is glabrous and which microscopically consists of globular cells; FIBRILLOSE-GLABROUS, referring to a cuticle which is truly glabrous, perhaps shiny, and not at all fibrillose or subtomentose even under a hand lens, but which microscopically is seen to be composed of matted or interlaced hyphae.

Under the higher powers of a binocular dissecting microscope, or occasionally under a hand lens, the hyphal nature of a FIBRILLOSE-GLABROUS surface is usually readily detected, but the hyphae are more or less matted and often fused, at least in strands, often making a macroscopically shiny surface, while a

GLOBULOSE-GLABROUS surface on the other hand, is pebbly or cobbled when magnified. It is believed that greater clarity could be attained if the terms "tomentose" and "subtomentose" could be used only when the surface is distinctly and definitely woolly under a hand lens; "fibrillose" when the fibrils are quite distinct from the layer from which they arise and upon which they rest; and "glabrous" for all conditions of smoothness in which no details of surface structure are absolutely distinct under a hand lens, in which there are no hyphae or fibrils loose or separable from the pellicle proper, or in which hyphae are at all massed, matted or coalesced in such a way that the identity of individual hyphae or fibrils is not plain. Resort to the microscope will then clarify the fundamental nature of the glabrous condition.

It is suggested that these newly proposed terms be used only as referring to microscopic details and that "fibrillose-glabrous" be not used for a condition which may seem more or less glabrous with some fibrillar elements.—WALTER H. SNELL, BROWN UNIVERSITY, PROVIDENCE, R. I.

#### NOTICES

The headquarters of the Mycological Society of America at the Atlantic City meeting of the A.A.A.S., Dec. 28, 1936, to Jan. 2, 1937, will be at the Ambassador, Boardwalk at Brighton Ave. This hotel is also the headquarters of related botanical societies. The rates for rooms are \$3.00 to \$6.00 a day for a single room and \$6.00 to \$10.00 a day for a double room with twin beds. All rooms are with bath, and on the European Plan.

Institutions or individual members of the Society desiring space for their exhibits should write directly to F. C. Brown, Director of Exhibits, Smithsonian Institution Building, Washington, D. C. The A.A.A.S. pays the cost of booth rental for exhibits from Educational Institutions. Since a goodly proportion of the space is already taken, it is highly advisable that members who wish to exhibit for themselves or their institution apply as soon as possible.

The 100th meeting of the A.A.A.S. will be held at Denver in June 1937. This will be a joint meeting of the Pacific, South-western, and Eastern Divisions and thus will give an excellent opportunity to meet colleagues from all parts of the country in a location that is "a delightful one both for summer activities and also by virtue of the many attractions it offers for those interested in different fields of science and to lovers of nature. . . ." The Executive Committee of the A.A.A.S. plans to have special features and hopes to welcome distinguished visitors from abroad to add emphasis to the One Hundredth Meeting. It is hoped that all those that can possibly arrange to do so will plan to attend the meeting at Denver.

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#### NOTE ON THE DISTRIBUTION OF FUNGI

The extreme minuteness of the spores of many species of fungi is doubtless an important factor in contributing to their ubiquity. The author of a work on botany has professed to the belief that a vigorous kick delivered to a large ripe puffball can raise spores that may be caught into air currents capable of carrying them around the globe.

Butler and Bisby in their *Fungi of India* devote eight pages to a comparison of the known fungi of that country with those of Europe and temperate America. Twenty-one per cent of the Manitoba rusts are already known to occur in India. In S. C. Teng's list of Chinese Discomycetes out of over 50 species described in his list only three had not been previously described as European or American. In 1931, the veteran Danish agari-cologist, Jacob E. Lange, made a trip across the middle latitudes of this continent for the express purpose of comparing the fleshy fungi of the region traversed with those of Europe. The last statement in his interesting report of the trip in the first twelve pages of *MYCOLOGIA*, Volume XXVI, is that his strongest impression was of the evidence of the wonderful cosmopolitanism of the Agarics. He concludes with the question—Who can trace the aerial course of a spore?

Another Danish botanist who has worked on Arctic fungi for thirty-five years—Jens Lind—has summarized his researches on

their circumpolar distribution published in English in Meddelelser, Vol. XI, Part 2, 152 pages. He has not found a single genus peculiarly indigenous to the polar regions. Species that followed the retreating ice cap and those that climbed the mountains keeping near the snow line, although separated now for 15,000 years, have not evolved any noteworthy differences.—  
JOHN DEARNESS.

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVIII

NOV.—DEC., 1936

NO. 6

## A NEW SPECIES OF ARACHNIOTUS

J. W. HOTSON

(WITH 13 FIGURES)

The genus *Arachniotus* was created by Schröter in 1893 for the reception of *A. candidus* (Eidam) Schröt. (1, 2a, 3), and *A. aureus* (Eidam) Schröt. (2a, 3), previously referred to the genus *Gymnoascus*. In these species the ascospores are hyaline, yellowish, or red; the fruit-body globose or sub-globose, and the peridium composed of loosely interwoven hyphae of more or less uniform size and without any special appendages. On these characteristics the new genus, *Arachniotus*, was based. The first species, considered the type, was found growing on well-rotted manure in Germany, and in 1901 on an old nest of wild bees, and on dung of the common Roe at Kew, England (1); the fruit-bodies .5–2 mm. in diameter, hyaline; asci ovate; ascospores 3–3.5  $\mu$ , hyaline and smooth. The second species was found on decaying vegetables, on wet paper, and on bread in Silesia; the fruit-bodies globose, 1.5–1 mm. in diameter, yellow, hyphae somewhat spiral; asci 8-spored; ascospores 3.5–4  $\mu$ , yellowish, and minutely spiny. Later *A. ruber* (Van Tiegh.) Schröt. (2b, 4) was transferred to this genus. It is a coprophilous form reported from France, Germany, and Britain in Europe and from the Gold Coast in Africa. The distinguishing character of this species is the color of the fruit-body which is pale-yellow at first, but soon turning orange,

[MYCOLOGIA for September–October (28: 399–496) was issued  
October 1, 1936]

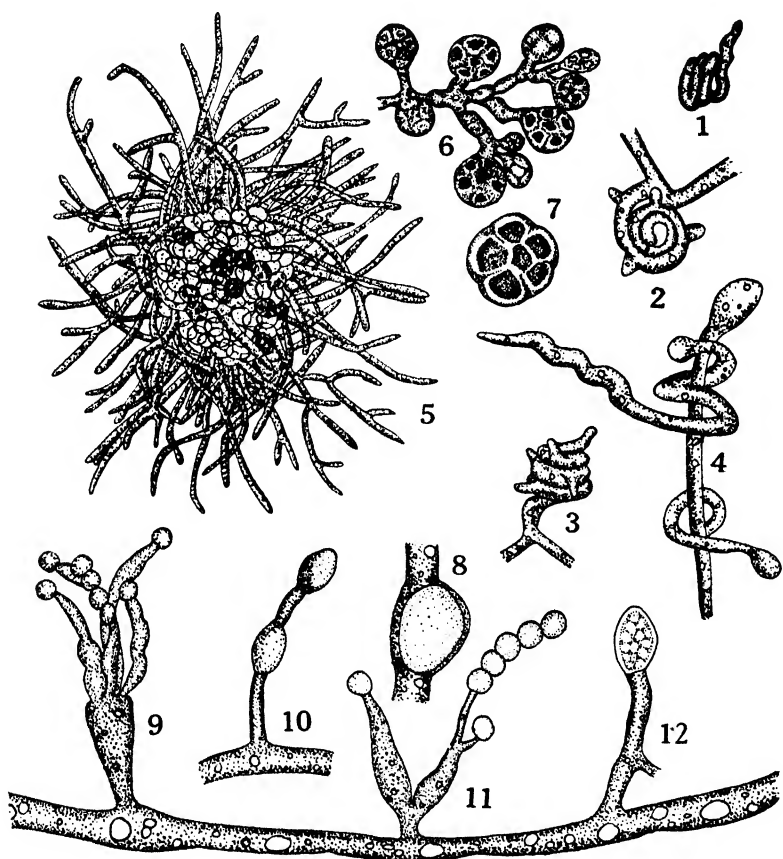
and finally becoming dark reddish-orange. In 1902, two other species were added to the genus. The first of these, *A. citrinus* Mass. & Salm. (1, 2b), was found on the dung of the giant Kangaroo at Kew in England, the fruit-bodies sub-globose, .5–1 mm. in diameter, hyaline at first, becoming bright lemon-yellow, the spores also yellowish; and the second, *A. trachyspermus* Shear (2b, 5, 6) found associated with diseased cranberries grown in New Jersey, is the only species reported for North America. The lemon-yellow, echinulate ascospores, the size of the fruit-body (325–425  $\mu$ ), and the absence of chlamydospores are the most marked differences between the last species and the one under consideration.

Besides *Arachniotus* there are four other closely related genera belonging to the Gymnoascaceae. Of these *Amaurascus* is distinguished by its brown or brownish-violet ascospores, while the other three genera differ in the character of the peridium of the fruit-body. All three of these have peridia with interwoven hyphae, armed with spines or prongs in *Gymnoascus*; with circinate appendages at the tip in *Myxotrichum*; and appendages comb-like in *Ctenomyces*.

In 1914 another species of *Arachniotus* was isolated from contaminated milk sent to the Botany Department of the University of Washington. This organism proved to be an interesting one and has been used for over twenty years as one of the types studied in the classes in mycology. It grows readily on almost any medium and the different stages in the development of the ascocarp are relatively easy to follow. The medium commonly used was Thaxter's potato-agar. Cultures less than a week old produce conidia. About the same time or a few days later, on the same mycelium, chlamydospores are developed and in two to three weeks the ascocarps with asci and ascospores appear.

The *mycelium*, as it appears in cultures, is procumbent and almost pure-white, becoming slightly yellowish with age. The diameter varies from 2.7–4.5  $\mu$ . Not infrequently, however, swollen cells (8–11  $\mu$ ) are developed which seem to be food-storage organs. The *conidia* are hyaline, one-celled, slightly elliptical, 3.5–4.5  $\times$  4.5–5.5  $\mu$ . They are produced in chains on bottle-shaped sterigmata which are formed on short lateral branches, scattered

over the hyphae or sometimes several on an erect conidiophore approaching in appearance species of *Penicillium* (FIG. 9). The *chlamydospores* vary somewhat in form but are usually more or



FIGS. 1-12. *Arachniotus trisporus*. 1-4, stages in the development of the primordium; 5, the ascocarp showing asci in the center and the loosely interwoven hyphae forming the peridium; 6, an ascogenous branch showing asci and ascospores; 7, a mature ascus; 8, a food storage cell; 10 and 12, chlamydospores; 9 and 11, conidia.

less pear-shaped,  $6-7 \times 7-11 \mu$ , formed singly at the ends of short branches. Rarely are they intercalary. These spores have thick walls, a characteristic which makes it possible for the fungus to be tided over fairly long periods of adverse conditions.



In cultures about two or three weeks old, primordia of the ascocarp may be found. These consist of a spiral ascogonium closely surrounding a central branch, the *antheridium* (FIG. 1-4). This central body is not always present—in some instances the coil was formed but no evidence of the central cell was observed. From the cells composing the spiral, branches are produced. These may divide and subdivide, the ends of the ultimate branches forming the asci, in a manner similar to those reported for allied genera of the Gymnoascaceae.

The mature ascocarp is sessile, more or less globose or slightly flattened,  $160\text{--}326\ \mu$  in diameter. At times several of these are formed close together and often merge into each other, forming a sort of compound fruit-body. The peridium is composed of loosely interwoven, undifferentiated hyphae. In the center of the ascocarp numerous asci are produced forming a compact mass. These are elliptical to nearly globose,  $7\text{--}9 \times 10\text{--}11\ \mu$  in diameter, and eight spored. The wall of the ascus soon becomes gelatinized and disappears, but the eight spores are held intact for a considerable time. The ascospores are thin-walled, hyaline, smooth, elliptical, measuring  $3.5 \times 5.5\ \mu$ . After they become separated from the ascus they resemble very closely the conidia in size and color and might easily be mistaken for them.

This species is distinguished by the white mycelium, the smooth ascospores, the small size of the fruit-body, and the presence of three kinds of spores in its life cycle. It is thus morphologically different from any other species described for this genus, and since it has three distinct spore-forms, the name *Arachniotus trisporus* is proposed.

### ***Arachniotus trisporus* sp. nov.**

*Mycelium* hyaline, procumbent, becoming slightly cream-colored with age; *fruit-bodies* sessile, more or less globose,  $160\text{--}326\ \mu$  in diameter, wall composed of undifferentiated cobwebby hyphae which are simple or branched; *asci* elliptical to globose,  $7\text{--}9 \times 10\text{--}11\ \mu$ , eight-spored; *ascospores* hyaline, smooth, elliptical,  $3.5 \times 5.5\ \mu$ ; *conidia* hyaline, elliptical,  $3.5\text{--}4.5 \times 4.5\text{--}5.5\ \mu$ , on bottle-shaped sterigmata, catenulate; *chlamydospores* subglobose to pyriform,  $6\text{--}7 \times 7\text{--}11\ \mu$ , solitary on the ends of short branches.

Obtained from cow's milk in Seattle, Wash., U. S. A.

*Mycelio tenui*, noveo, effuso; ascomatibus globosis vel sub-globosis  $160\text{--}326\ \mu$  diam., laxis arachnoideis ex hyphis formatis; ascis globosis vel sub-globosis, octosporis; sporidiis ellipsoideis, hyalinis, levibus,  $3.5 \times 5.5\ \mu$  diam.; conidiis catenulatis, ellipsoideis,  $3.5\text{--}4.5 \times 4.5\text{--}5.5\ \mu$ ; chlamydosporicis, piri-formibus,  $6\text{--}7 \times 7\text{--}11\ \mu$ .

Habitat in lacte bubulo, Seattle, Amer. bor.

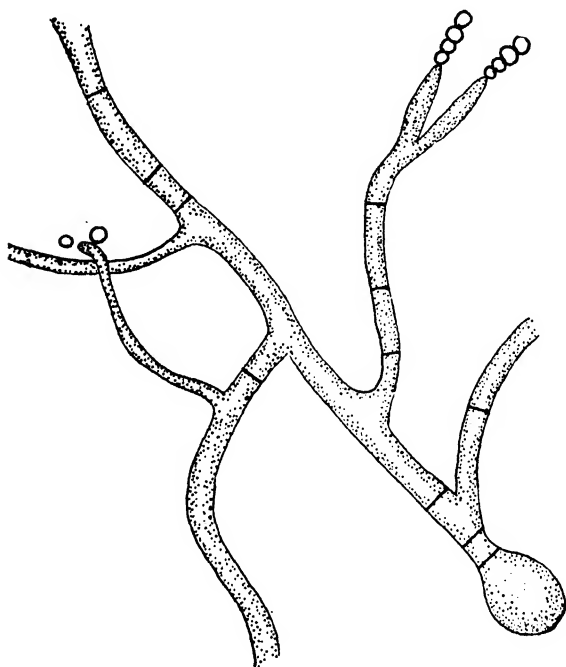


FIG. 13. A germinating chlamydospore.

#### THE LONGEVITY OF THE FUNGUS

A remarkable characteristic of this species is the length of time it holds its vitality. This was brought to the writer's attention immediately after the World War when he found his cultures which had been neglected for more important work, nearly all dead or over-run with mites. The cultures of *Arachniotus* were completely destroyed by mites. Fortunately there were some old, dried-up tubes that were made in 1917 still available. Cultures from these grew readily. In an effort to determine how long this

fungus would hold its vitality in a dry condition these old cultures which were originally made of potato-agar, were set aside. Eight years later, 1925, transfers were made from these tubes with positive results. The question then arose as to what part of the fungus held the vitality—the mycelium, the conidia, chlamydospores, or ascospores. As was expected, all cultures from the dried-up mycelium failed to grow. Van Teigham cells of the spores were made and the chlamydospores were the only ones that germinated. Every year from 1925 to 1936 similar cultures were made and each year showed only the chlamydospores germinating. The drawing in fig. 13 was made in 1936 from cultures made from the 1917 material. It is planned to test these cultures each year until they lose their vitality.

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SEATTLE

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# A NEW SPECIES OF MICROASCUS WITH A SCOPULARIOPSIS STAGE

PHILIP M. JONES

(WITH 24 FIGURES)

## INTRODUCTION

During the fall of 1931, Doctor D. C. Smith, Professor of Dermatology and Syphology at the University of Virginia, gave me some dermatophyte cultures growing on Sabauraud's media. He had obtained a fungus in December, 1931, from an infection showing eruptions involving the hands and forearm and it was from the culture of this fungus that I found what I believe to be a new species of *Scopulariopsis*.

On Sabauraud's media the surface growth of this new species was smooth with a whitish growth becoming grayish mealy with the formation of conidia and then turning black with the formation of the ascocarps. The colonies were restricted in extent and became wrinkled and raised above the surface of the agar. One could not consider this a surface growth as a number of the hyphae penetrated one fourth of an inch into the agar. There was very little or no growth on dextrose-tartaric acid media.

In my study of dermatophytes, I have found that those within my experience grow better in Knop's solution in a sterile moist chamber than on agar media. Consequently, the study of all stages of the above fungus except the cross section of the perithecial stage, was made from culture grown on Sabauraud's media. The perithecia develop abundantly, however, in Knop's solution.

## **Microascus lunasporus** sp. nov.

On Sabauraud's medium forming a smooth whitish colony, becoming grayish and mealy as conidia develop, then black with the formation of ascocarps, becoming wrinkled and raised above the surface of agar; mycelium of branched septate hyphae 2-3  $\mu$  diameter; no growth on dextrose-tartaric acid media. Conidia produced directly on the mycelium, or on simple or branched conidio-

phores with sterigmata  $5-12\ \mu$  long; conidia oval to lemon shape, with a collar at the base,  $2-4 \times 4-7\ \mu$ . Perithecia developing abundantly on Sabouraud's medium and in Knop's solution,  $175-300\ \mu$  diameter, beaked and with a papillate ostiole, the wall consisting of an outer layer 5 to 8 cells thick, with heavily carbonized walls, and an inner layer of thin-walled colorless cells; asci oval,  $7-12 \times 7-14\ \mu$ , irregularly distributed, eight spored, deliquescing at an early stage; spores lunate,  $4-7 \times 8-14\ \mu$ , smooth, extruded in light reddish-brown cirrhi  $30-50\ \mu$  diameter and reaching a length of one mm.

Type culture isolated from an infection on a human hand. Slides from sub-cultures deposited at the New York Botanical Garden.

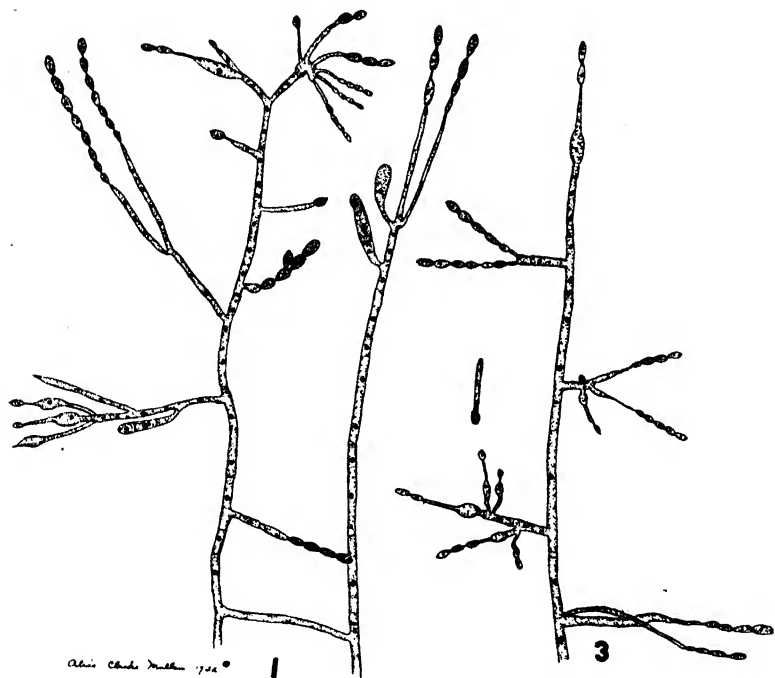
The conidial stage of this fungus is to be designated as **Scopulariopsis lunaspora** sp. nov.

The ascocarp arises from two cells which can readily be distinguished from the cells in the rest of the hyphae because these cells do not destain and always remain black while the rest of the sterile cells readily destain when stained with Haidenhain's iron haematoxylin, short method (FIG. 4-7). One of the dark staining cells first sends out dark stained ascogonium branch with one nucleus. The nucleus undergoes division as the ascogonium branches and a cross wall is formed separating each nucleus. The other dark staining cell, near or adjoining the dark staining cell that the ascogonium arose from, sends out a dark staining antheridium branch which is smaller than the ascogonium branch. The nucleus in the antheridial branch divides and the dark staining antheridial branch becomes septate.

The antheridium coils around the ascogonium branch. The nucleus from one cell in the antheridium passes over into a branch of the ascogonium and becomes paired with the ascogonium nucleus.

Rapid division of the nuclei follows as the ascogenous hyphae branch. The sterile cells in the original hyphae then begin to put forth hyphae which bend towards the ascogenous hyphae and begin to envelop or twine around the ascogenous (from this stage, one is dependent on sections through the perithecium). The ascogenous hyphae become enveloped in a hypha weft of several layers of cells. This envelope later becomes differentiated into an

outer wall of dark colored carbonized cells and an inner portion consisting of thin-walled colorless cells. The cells immediately surrounding the ascogenous hyphae began to elongate inwardly, crowding in to fill up the space made available because of intercalary growth of the outer wall. A papillate ostiolar portion is then organized and its cavity forms schizogenetically. Because the outer wall increases in its circumference more rapidly below and at



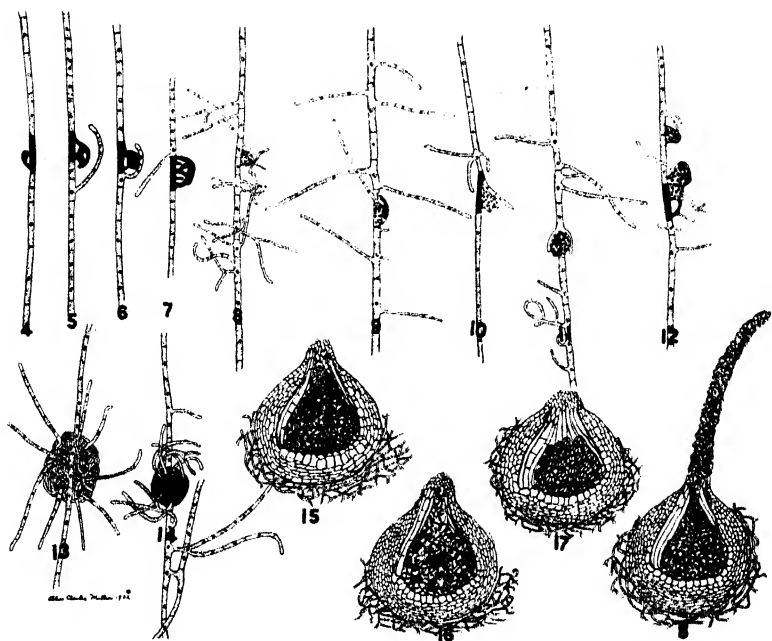
FIGS. 1-3.

the sides than at the top, and because the inward-growing hyphae develop more rapidly from below than from above, the ascogenous hyphae become placed well above the center and just beneath the ostiole. The ascogenous hyphae branch in a downward direction. The asci arise as side or terminal branches of the ascogenous hyphae. The first asci form in the region near the location of the ascogone. The ripening of asci proceeds from this region peripherally, following the direction of growth of the ascogenous hyphae. The sterile cells are gradually absorbed and their place in

the cavity is taken by ascospores set free as the asci deliquesce. The ascospores are discharged in large, slender cirrhi containing a cementing substance which hardens on drying and which is then dissolved in water only, very slowly.

#### ASEXUAL STAGE

The mycelium is composed of branching septate hyphae 2 to 3  $\mu$  in diameter. The conidiophores may be lacking, or when present are either simple or branched. The conidiophore may bear at the tip, a chain of spores, a single vertical sterigma or a many branched sterigma 5 to 12  $\mu$  long. The conidia are brown oval to lemon shape, with a collar at the base 2-4  $\times$  4-7  $\mu$ . Germination takes place from the side.

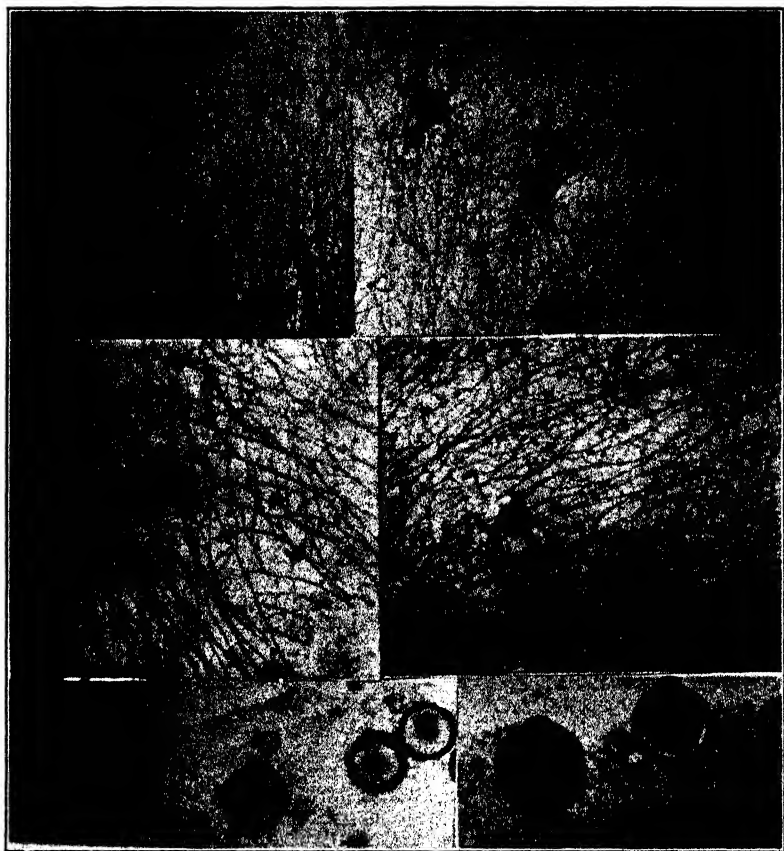


FIGS. 4-18.

#### SEXUAL STAGE

Ascogonium is coiled. The antheridium generally comes from the adjoining cell in the same hypha. The ascocarps have papil-

late ostiole with a beak, 175 to 300  $\mu$  in diameter in Knop's solution. The outer five to eight layers of cells are heavily carbonized, the ascogenous hyphae grow downward from the ascogonium which is then located well up under the ostiole. Asci are oval and  $7-12 \times 7-14 \mu$ . The asci are irregularly distributed and in gen-



FIGS. 19-24.

eral, orientated towards the periphery of the ascocarp and away from the ascogonium. The asci are eight-spored and are deliquescent within the ascocarp. Ascospores are lunate-shaped  $4-7 \times 8-14 \mu$  and are discharged from the dying ascocarp as a long, light reddish-brown cirrhous  $30-50 \mu$  in diameter and reaching a length of one mm. (FIG. 17).



## DISCUSSION

The technique employed in growing, fixing and staining these fungi is different from that usually followed by mycologists and will be described in a later paper.

This new species is very similar to *Microascus trigonosporus*. Since *M. trigonosporus* has been excellently described by Emmons and Dodge (1), I will not give a full description of this *Scopulariopsis* in this paper but will relate certain details in which it differs from *M. trigonosporus*.

I have found that this species of *Scopulariopsis* is an ascomycete with a *Scopulariopsis* conidial stage and an ascocarp stage which corresponds to *Microascus* except that it has lunate-shaped ascospores. *Microascus sordidus* has kidney-shaped ascospores and *Microascus trigonosporus* has triangular ascospores.

This new species of *Scopulariopsis* described as *Microascus lunasporus* and the conidial stage is referred to as *Scopulariopsis lunaspora*.

Emmons and Dodge (1) did not describe the asexual stage in *Microascus intermedius*, therefore, I cannot compare that species with *Microascus lunasporus*. I have five different species growing now in which the sexual stages are quite similar but there is a marked difference in the asexual stage of each and in the cultural habits especially in their power to reduce cellulose. These five species will be described fully in a later paper.

Prepared slides deposited at The New York Botanical Garden.

## SUMMARY

The writer has studied in culture an ascomycete having a *Scopularopsis* conidial stage and an ascocarp stage very similar to the one described by Emmons and Dodge which corresponds to *Microascus* except that it has lunate-shaped ascospores whereas *Microascus trigonosporus* has triangular ascospores and *Microascus sordidus* has kidney-shaped ascospores. The new species is described as *Microascus lunasporus*. The ascocarp arises from two cells which shows great affinity for Haidenhain's haematoxylin stain, the ascogenous hyphae coming from one cell and the antheridium from the other. The antheridium is septate and fertilizes

the ascogenous hyphae in the two-cell stage. After pairing, the nuclei undergo rapid division as the ascogenous hyphae becomes enveloped in a hypha weft of several layers of cells. Later this envelope becomes differentiated into an outer wall of dark-colored carbonized cells and an inner portion consisting of thin-walled colorless cells. These sterile cells are gradually absorbed and their place in the cavity is taken by ascospores set free as the asci deliquesce. The ascospores are discharged in long cirrhi containing a cementing substance which hardens on drying and which then is dissolved in water only very slowly.

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#### EXPLANATION OF FIGURES

Fig. 1, enastomosing hyphae with nuclei showing conidiophores and conidia; 2, conidia germinating; 3, simple hyphae with conidia; 4, two cells in hyphae staining dark, one cell producing an ascogenous hyphae and the other dark cell will produce the antheridium; 5 and 7, ascogenous hyphae branched with nucleus in each branch; the septate antheridium fertilizing the ascogenous hyphae, while the sterile hypha is curving in to form the perithecium wall; 6, ascogenous hypha nuclei undergoing rapid division as the sterile hypha bends in; 8, adjoining hyphae will shoot out a branch hypha when they lie near the formation of an ascocarp on a different hypha; 9-12, the nuclei after fertilization undergo rapid division before the ascocarp is formed; 13 and 14, ascocarp formed; 15, medium longitudinal section of a perithecium showing the papillate ostiole and the formation of asci; 16 and 17, section through a mature ascocarp filled with asci; 18, ascospores being extruded from the ascocarp in a cirrhous.

# A NOTE ON THE TEMPERATURE RELATIONS OF CERTAIN FUNGI

NEIL E. STEVENS

(WITH 1 FIGURE)

Advantage was taken of an unusually accurate series of temperature chambers, which have been maintained for more than a year under the immediate care of Dr. A. G. Johuson in the laboratory of the Division of Cereal Crops and Diseases of the Bureau of Plant Industry, to test in culture the temperature relations of the species of "*Diplodia*" common on corn, as well as of a group of apparently closely related fungi which the writer has been studying for a number of years. The temperature intervals are 5° C., and it is thus not possible to determine exact maximum or optimum temperatures with great accuracy. This, however, does not seem important since it is their relative growth which is of greatest interest.

The method used was to grow the fungi on agar plates from mycelial transfers, average a number of different series, usually 6 to 10, run at different times, and reduce all readings to radial growth in a 24-hour period. Results of the tests on corn meal agar are given in the graphs (FIG. 1). Other culture media were used and, of course, the growth rate varied somewhat with the medium. The relative rate, however, remained the same. None of the fungi showed measurable growth at 5° or at 40°. No doubt, within each of these morphological species there could be found races with temperature relations somewhat different from those here indicated, but these are believed to be typical, and are averages of available material, including in as many cases as possible cultures originating from ascospores and pycnosporos. Without attempting to insist on their significance, attention may be directed to certain apparent correlations.

## GEOGRAPHICAL DISTRIBUTION

*Diplodia Zeae* (Schw.) Lév., the common corn "*Diplodia*," apparently occurs to some extent almost throughout the range of its host, but is least important toward the northern limits of corn cultivation, and in the drier areas.

*Diplodia macrospora* Earle is less well-known but has been reported on corn from the United States, South America, and South Africa.

*Physalospora obtusa* (Schw.) Cooke (*Sphaeropsis malorum* Peck) (cause of the common black rot of apple). This fungus is abundant throughout the eastern United States, rare in California, present but apparently not abundant in Europe.

*Diplodia megalospora* Berk. & Curt. has been reported from South Africa and is scattered but apparently not particularly abundant throughout the eastern United States from Virginia northward.

*Botryosphaeria Ribis* G. & D. is widely scattered in the tropics and common in southeastern United States. One form (*chromogena*) causes the cane blight of currant, destructive during certain periods as far north as the Hudson Valley, New York.

*Botryosphaeria melanops* (Tul.) Winter has been collected much more rarely than the preceding, and has been found thus far only in Europe and the northeastern United States.

*Physalospora mutila* (Fries) N. E. Stev. (*Sphaeropsis malorum* of Berkeley) is fairly common in Europe and occasionally found in the northwestern United States.

*Physalospora glandicola* (Schw.) N. E. Stev. has been collected only a few times, all in the northeastern United States and adjacent Canada.

*Diplodia natalensis* Pole-Evans is common and widely distributed in the tropics, and in the southeastern United States.

*Diplodia sarmentorum* Fries is very common in Europe and occasionally found in the northwestern United States.

Comparison of the temperature relations of these fungi with their known distribution shows that the corn fungi have a relatively narrow temperature range, with no growth at 10° or 35° C.

Within the "*Melanops*" group (*Botryosphaeria* and *Physalospora*) two species only show any considerable growth at 35° C.

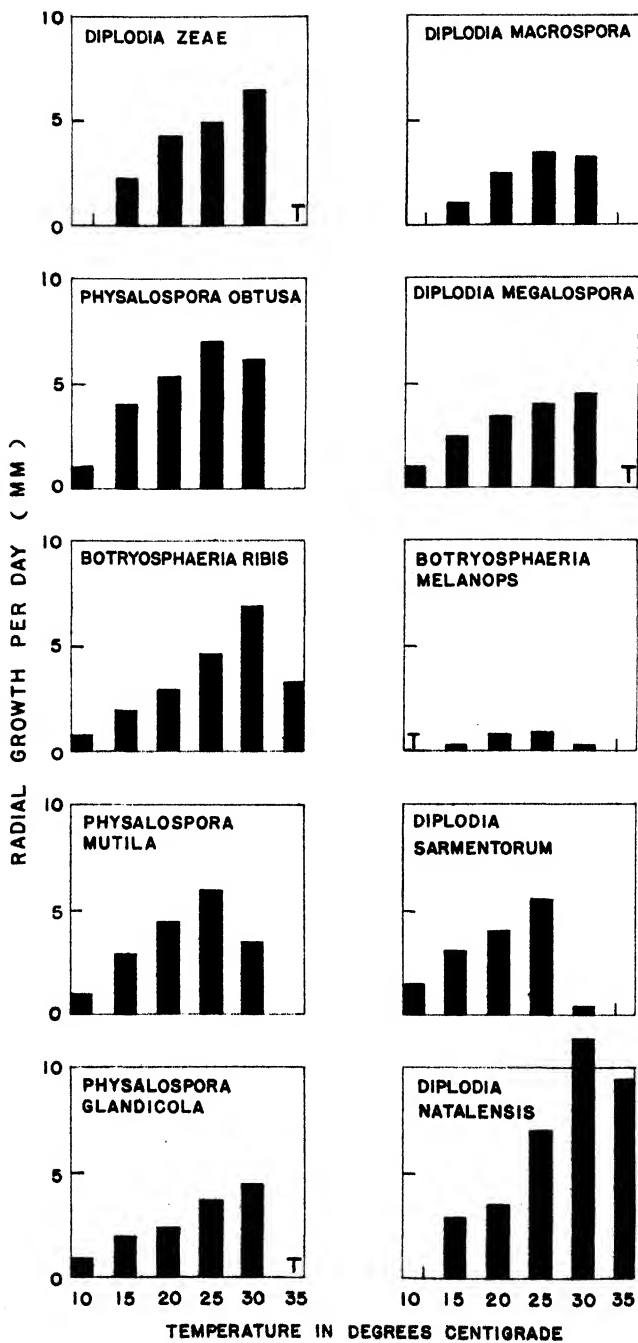


FIG. 1.

These are *Botryosphaeria Ribis* and *Diplodia natalensis*, both of which are widely distributed in the tropics. Species whose range is well known and which are relatively abundant in the North Temperate regions all show good growth at 10°, and have their optima around 25° or 30°, i.e., *Physalospora glandicola*, *P. obtusa*, *P. mutila*, *Diplodia sarmentorum*, *D. megalospora*, and *Botryosphaeria Ribis*. The one with the widest temperature range is *B. Ribis*, which has also the greatest known north and south distribution. It would, of course, be unwise to push these correlations too far but if similar information had been available 20 years ago, when we first took up the study of the currant cane blight caused by *B. Ribis*, we might not have delayed 10 or 12 years before looking for this fungus in the tropics.

#### SIZE OF SPORE AND GROWTH RATE

Included in the study were three "pairs" of species very similar in general appearance and in shape of pycnospores, but in each case the pycnospores of one are much larger than those of its counter-type. The pairs are, with the small-spored fungus named first in each case, *Diplodia Zeae* and *D. macrospora*, *Physalospora obtusa* and *D. megalospora*, *Botryosphaeria Ribis* and *B. melanops*. So similar except for size are the pycnospores of these "pairs" within the "Melanops" group that it is easy to deceive even a very skilled observer as to their identity by changing the objective of the microscope. In the case of the two species of *Botryosphaeria*, of which alone the ascospore stage is known in both members of the pair, the same relation exists in the ascospores, i.e., they are identical in shape and general appearance, but *B. melanops* is much larger than *B. Ribis*.

It will be noted that the *ranges* of the two members of each "pair" are much the same, but that in each case (and this applies on all culture media tried) the growth rate of the larger spored fungus is much slower, also that the larger spored form is apparently much less common and apparently less widely distributed in nature. Continued study of these fungi leads to the conviction that in some way not yet understood, these phenomena are related in a significant manner.

# NORTH AMERICAN SPECIES OF SCLEROTINIA AND RELATED GENERA.<sup>1</sup> III. CIBORIA ACERINA<sup>2</sup>

H. H. WHETZEL AND N. FABRITIUS BUCHWALD<sup>3</sup>

(WITH 19 FIGURES)

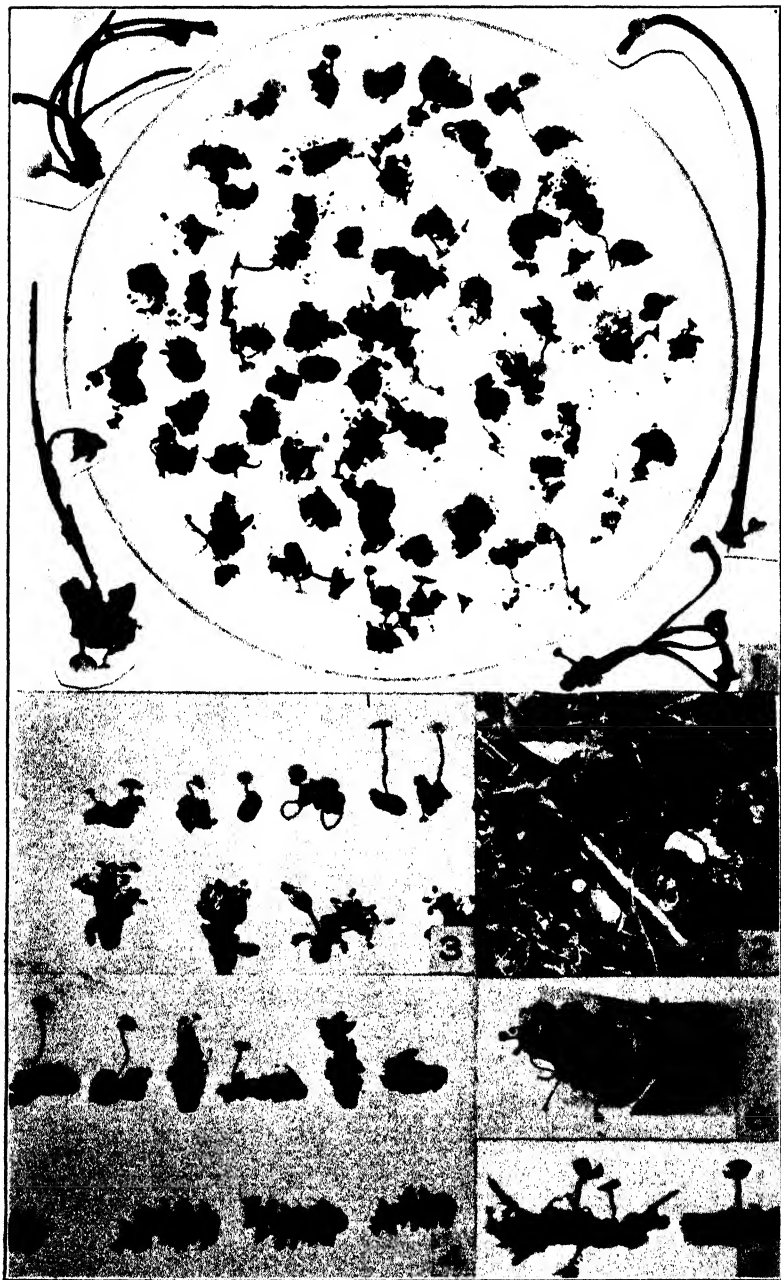
This species was first collected by E. E. Honey in 1926, in the South Hill Swamp, Ithaca, N. Y., on the overwintered staminate inflorescence of *Acer rubrum*. It has been taken by the senior author nearly every spring since that time on *Acer saccharinum* (FIG. 1) and *A. rubrum* (FIG. 3) in localities about Ithaca, N. Y. It appears to be very common and is usually abundant on these hosts. It was collected on the overwintered female inflorescence of *A. rubrum* at Malloryville, N. Y., April 15, 1936; on male catkins of *Myrica Gale* (FIG. 4), at Labrador Lake, N. Y., April 18, 1927; on male catkins of *Salix discolor* (FIG. 5) in the Lloyd Preserve at McLean, N. Y., on May 1, 1928; and in the same locality on what appears to be a bud (male inflorescence) of *Ostrya virginiana*, May 5, 1933. It occurs in great abundance every spring on the over-wintered male inflorescences of *Acer saccharinum* on the campus of Cornell University.

This is one of the earliest species of *Ciboria* occurring in the region about Ithaca, its apothecia maturing and discharging the ascospores during April and May when its hosts are in bloom. The minute apothecia, 2–3 mm. in diameter, are usually to be found at this time in great numbers on the ground among the grass and leaves, beneath trees of the silver maple and red maple

<sup>1</sup> The title of this series of papers, of which two have already appeared, is thus modified to designate more adequately the field into which the senior author's taxonomic wanderings have led him.

<sup>2</sup> The investigations upon which this paper is based were supported in part by a grant from the Heckscher Foundation for the Advancement of Research, established by August Heckscher at Cornell University. The writers wish to acknowledge the assistance of Miss Cynthia Westcott, who, as Heckscher Research Assistant, contributed materially to the success of this investigation. The photographs were taken by W. R. Fisher. The drawings are by the junior author and Miss Ruby Rice.

<sup>3</sup> Fellow of the International Education Board, 1930–31.

FIGS. 1-6. *Ciboria acerina*.



(FIG. 2). They arise, one to several, from the black, mummified inflorescences which have lain on the ground through the previous summer, fall and winter. The species is readily recognized by the very small apothecia, the mummified flowers of its hosts and its 4-spored asci (FIG. 13). A thorough search of the literature discloses no already-described species to which our fungus can be referred (see *Notes* at the end of this article). We, therefore, present it as a newly described species to which we give the following name:

## DESCRIPTION

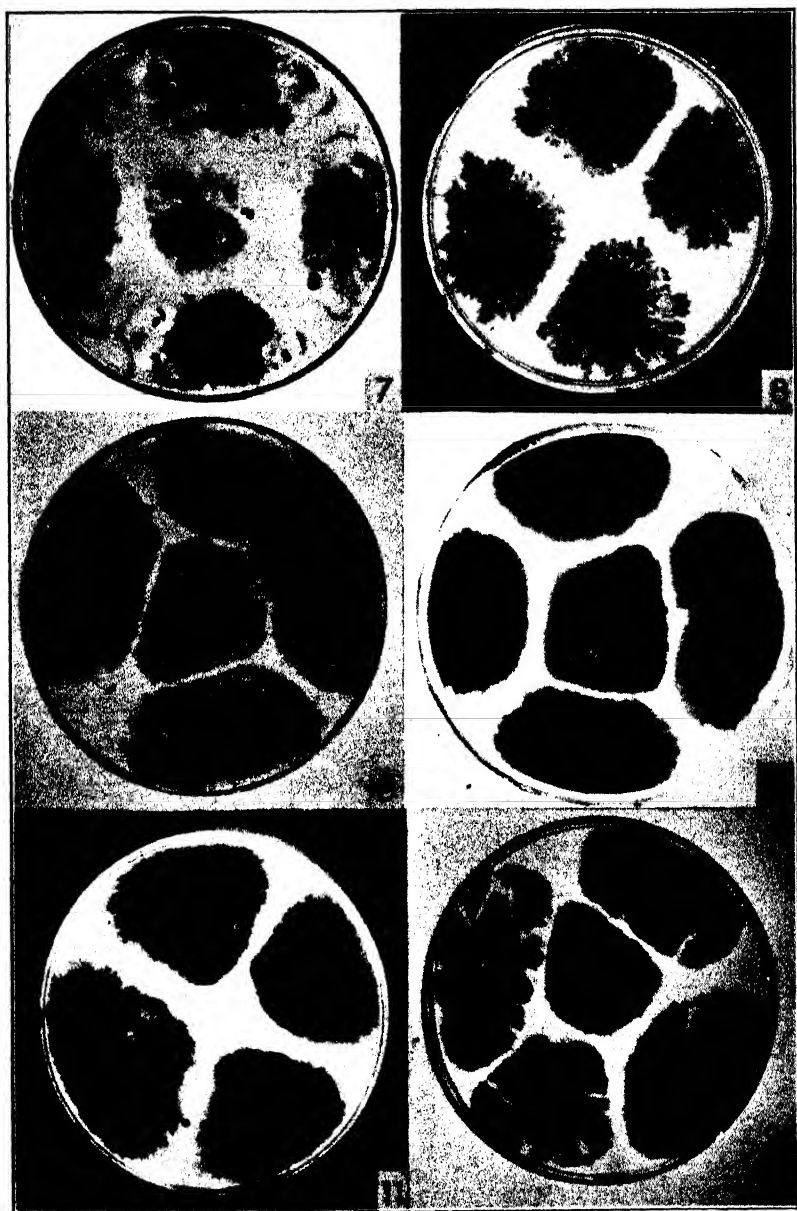
**Ciboria acerina** sp. nov.

Apothecia 1-several, from the black stromatized male (rarely the female) inflorescence of the host; small, 1-4 mm., usually 2-3 mm. in diameter. Disc wood brown, avellaneous or vinaceous buff (R<sup>4</sup>); broadly funnel-form to shallow cup-shaped, finally flat-expanded; margin often recurved in mature specimens. Stipe variable in length, 1-10 mm. long, smooth, somewhat darker than the cup. Under side of cup and stipe finely pubescent when young. Asci short and stout,  $75-107 \times 7.5-8.8 \mu$ , average  $92 \times 7.7 \mu$ , mode  $90 \times 7.5 \mu$ ,<sup>5</sup> always 4-spored; ascospores ellipsoid, slightly flattened

<sup>4</sup>R = Ridgway's Color Chart. The young apothecia are light colored, vinaceous buff, becoming avellaneous, finally wood brown with age.

<sup>5</sup>These figures are the results of measurements of 100 asci and 100 ascospores made on living material of the type specimen (21961). Similar measurements from some twenty collections (usually 50 asci and 100 ascospores) show relatively little variation. Variations in measurements of asci are usually of little significance, especially the length, which in these twenty-odd collections averages somewhat less than that of the type specimen. The following table will give some idea of the variation in size of ascospores to be expected in different collections of this species:

Collection	No. sp.	Limits (in microns)	Average $\mu$	Mode $\mu$
<i>Acer saccharinum</i>				
Herb. No. 21961.....	100	10.0-15.0 $\times$ 5.0-6.2	11.9 $\times$ 5.5	11.2 $\times$ 5.0
23397.....	100	7.5-16.3 $\times$ 3.8-6.3	11.9 $\times$ 5.9	11.9 $\times$ 5.0
<i>Acer rubrum</i>				
Herb. No. 15787.....	100	7.2-13.2 $\times$ 3.6-7.8	10.1 $\times$ 5.2	10.2 $\times$ 4.8
17461.....	100	10.2-14.4 $\times$ 3.6-6.6	12.0 $\times$ 5.4	12.0 $\times$ 5.4
17471.....	50	9.6-15.6 $\times$ 4.2-7.2	12.0 $\times$ 5.6	12.6 $\times$ 6.0
<i>Myrica Gale</i>				
Herb. No. 15152.....	100	8.7-15.7 $\times$ 4.3-7.0	11.7 $\times$ 5.2	11.5 $\times$ 5.1
15791.....	100	7.8-13.2 $\times$ 3.6-6.0	10.2 $\times$ 4.5	10.2 $\times$ 4.2
<i>Salix discolor</i>				
Herb. No. 17469.....	100	7.2-12.0 $\times$ 3.6-6.0	9.2 $\times$ 4.6	9.0 $\times$ 4.8
<i>Ostrya virginiana</i>				
Herb. No. 25110.....	100	7.5-15.0 $\times$ 3.8-6.3	11.1 $\times$ 4.9	11.3 $\times$ 5.0

FIGS. 7-12. *Ciboria acerina*.

on one side, hyaline, smooth, occupying the upper two-thirds of the ascus, uniseriate,  $10-15 \times 5-6 \mu$ , average  $11.9 \times 5.5 \mu$ , mode  $11 \times 5 \mu$ .<sup>5</sup> Paraphyses simple, slender, septate, gradually enlarging toward the tip, slightly longer than the asci. Microconidia globose, about  $3 \mu$  in diameter, borne on fasciculate, Indian-club-shaped conidiophores of the usual *Sclerotinia* type. On the overwintered male and female inflorescences of *Acer rubrum* L., and on the male inflorescences of *Acer saccharinum* L., *Myrica Gale* L., *Salix discolor* Muhl., and *Ostrya virginiana* (Mill.) K. Koch, on the ground or in leaf mold under the host. Known only from North America.

HERBARIUM MATERIAL. Type specimen, No. 21961, Plant Path. Herb. Cornell University on *Acer saccharinum*. Duplicate material from this same collection has been deposited in the following herbaria: Harvard University; The New York Botanical Garden; Kew Gardens, England; British Museum, London; Museum d'Histoire Naturelle, Paris; University of Upsala, Sweden; University of Toronto, Canada; University of Copenhagen, Denmark; and Mycological Collections, Bu. Pl. Ind., Washington, D. C.

The following additional collections among others are deposited in the herbarium of the Department of Plant Pathology, Cornell University, Ithaca, New York.

On *Acer saccharinum* L., Nos. 23397, 25106, 25109.

*Acer rubrum* L., Nos. 14178, 15153, 15787, 16191, 17470, 17471, 25247 (Female inflorescence).

*Myrica Gale* L., Nos. 15152, 15791, 25105.

*Salix discolor* Muhl., Nos. 17469, 16703.

*Ostrya virginiana* (Mill.) K. Koch., No. 25110.

#### CULTURAL CHARACTERS

Ascospore sowings on potato dextrose agar give a rapid mycelial growth. There is a fairly abundant development of webby aerial mycelium, being rather scanty in isolates from *A. saccharinum* but profuse and felty in isolates from *A. rubrum* (compare figures 7 and 10). At first white, the aerial mycelium gradually becomes greyish brown, especially in isolates from *A. rubrum* and *Myrica Gale*. As the stromata develop on the surface of the agar

the aerial mycelium becomes appressed forming a more or less dense felty covering over them.

The submerged mycelium is hyaline and sparse in isolates from *A. saccharinum*. Isolates from the other hosts produce a very abundant dense submerged mycelium, which quickly becomes dark brown, eventually almost black (FIG. 10, 11). In isolates from *A. saccharinum*, while the submerged mycelium slowly takes on the brown color, the hyphal mat never becomes dark brown due to the relatively sparse hyphal development (FIG. 7). Seen through the bottom of the plate, isolates from *A. rubrum* have an opalescent, bluish-black color over the central portion of the growth. The dark-brown margins are crenate or feathery.

The stromata develop as rather small, irregular, flat, thin crusts on the surface of the agar, strikingly evident in isolates from *A. saccharinum* (FIG. 7) but more or less hidden in isolates from the other hosts by the dark brown mat of aerial mycelium covering them; usually more or less zonately disposed.

#### LIFE HISTORY

Some special investigations made by the junior author during the spring of 1931 may first be briefly summarized.

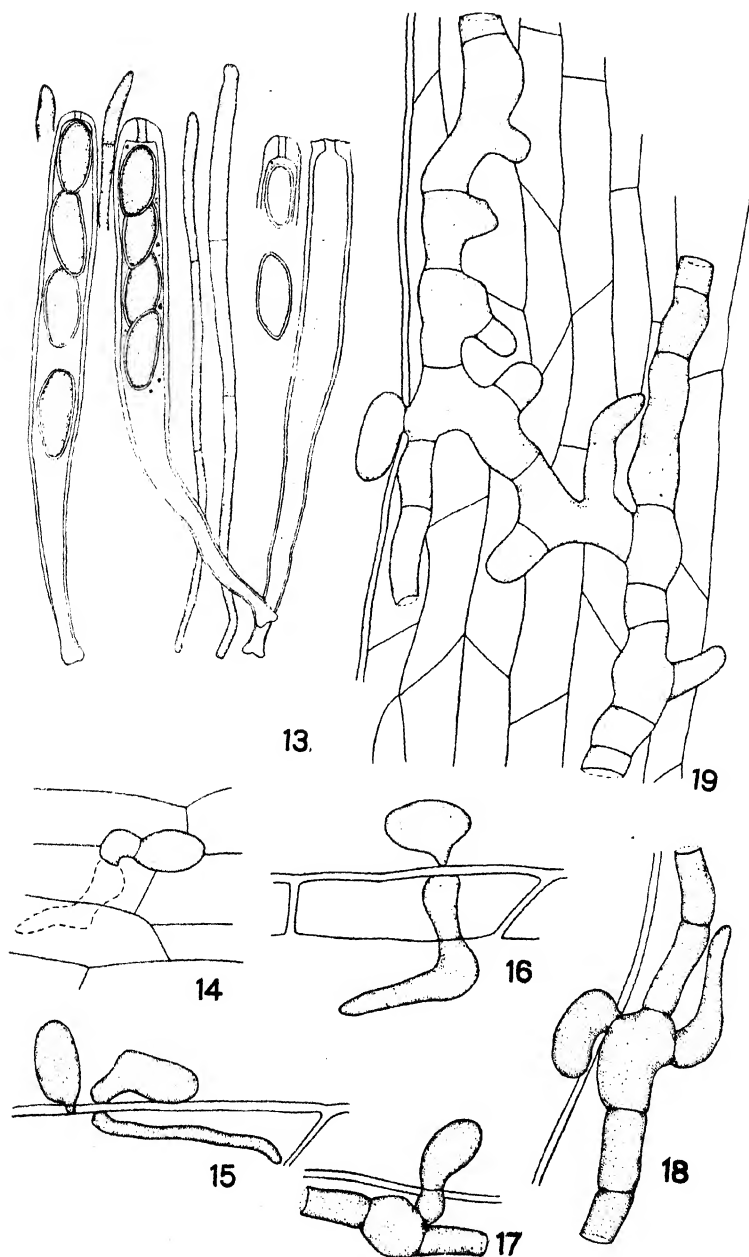
*Experiments on incubation and infection.* In order to determine whether *Ciboria acerina* is parasitic in the early stage of its life history, the following experiments were undertaken.

Twigs of *Acer rubrum* were cut on April 12, 1931, placed in water, and covered with a bell jar. Well-developed apothecia of *Ciboria acerina* were fastened to the twigs in such a position that the discharging ascospores would fall in abundance on the open flowers. Flowering twigs under another bell jar served as checks. After forty-eight hours, the bell jars were removed. The inoculated flowers already showed evidences of infection. They had begun to wither, while those in the checks were still fresh. Microscopic examination was made of the stamens and other floral parts at intervals of one, three, and six days after inoculation. The tissues of the inoculated flowers were stained in cotton blue lacto-phenol, and cleared in lacto-phenol. The germinating ascospores and mycelium took on a deep blue color, while the host tissues

remained unstained or of a much lighter blue color. The protoplasmic contents of the hyphae or of the host cells only were stained. It was observed that the ascospores had already germinated on the stamens after 24 hours, but in only a few cases had the germ tubes penetrated the epidermis (FIG. 14-16). After a period of seventy-two hours their germ tubes had penetrated the epidermis in great numbers, and rapid invasion of the tissues was under way (FIG. 17-19). After six days the filaments were found to be invested completely with mycelium. Spores which had fallen on the calyx and bud scales had germinated weakly or not at all, and there was no evidence of penetration. No trace of mycelium could be found in the stamens of the flowers in the check.

In order to determine whether this process of penetration and invasion of the stamens takes place under natural conditions in the flowers on the trees, staminate flowers were taken from a tree of *Acer saccharinum* underneath which there was an abundance of mature apothecia discharging spores. Using sterile instruments, anthers and filaments were carefully planted in potato dextrose agar in poured petri plates. At the same time apothecia were suspended above similar plates of potato dextrose agar and allowed to discharge their spores. Cultures thus obtained from the germinating ascospores and from the bits of planted stamens gave mycelial growths which were indistinguishable when compared. Transfers of mycelium from ascospore sowings and from the plantings of infected stamens were grown together side by side on potato dextrose agar in the same petri dish. Growing thus together, under identical conditions, no differences were to be observed in the mycelial growths from these two sources, indicating quite clearly that the fungus obtained from the tissue plantings of the stamens arose from invasion by *Ciboria accrina* which had already taken place while the flowers were still on the trees.

To make sure, however, that cultures obtained by tissue plantings from these stamens had not originated simply from ascospores adhering to the surface of the stamens, flowers which presumably were already infected were collected on April 20, 1931, from the trees of *Acer saccharinum* under which apothecia were abundant. Microscopic studies of these stamens stained with cotton blue as



FIGS. 13-19. *Ciburia acerina*.

described above showed numerous germinating ascospores, and in many cases the filaments were completely invaded by the mycelium.

Thus by microscopic examination of artificially inoculated flowers and of flowers naturally inoculated, as well as by comparison of cultures made from ascospore sowings and from tissue plantings from infected flowers, it seems to be clearly demonstrated that this fungus is parasitic upon the anthers and filaments of living stamens, and thus that invasion and initial infection of the hosts of *Ciboria acerina* occur only through the stamens. No evidence of infection of female flower parts was obtained although they also were inoculated. However, the discovery in the spring of 1936 of apothecia of what is undoubtedly *C. acerina* on the overwintered pedicels of female flowers of *A. rubrum* indicates that these organs are attacked in nature, although perhaps rarely.

*Outline of life history.* From these studies and from extensive field observations by the senior author over a period of ten years, the essential features of the life history of this *Ciboria* as it occurs on its *Acer* hosts may be outlined as follows.

The apothecia developing from the stromatized inflorescences and bud scales mature and begin the discharge of the ascospores at the time the flowers of the maples are beginning to open. At Ithaca, New York, spore discharge usually begins late in March or early April, depending on the character of the spring weather. Specimens of mature apothecia still discharging spores may be found usually over a period of three to four weeks. The latest time at which collections of this fungus have been made is May 21. During essentially this same period, collections of mature apothecia are to be found occasionally on the male catkins of *Myrica Gale* and *Salix discolor* in localities where the fungus is abundant under neighboring trees of *Acer rubrum*. Three collections on *Myrica* and two on *Salix* have been taken thus far. One collection has been taken on a single overwintered bud of what is apparently *Ostrya virginiana*. It is probably common and abundant on *Myrica*, but apparently rare on *Salix discolor*, because every spring for twenty years the writer has looked for and collected *Ciboria caucus* on the male catkins of *Salix* species. If *Ciboria acerina* were common on the male catkins of willows, many more collections should have been taken on this host. It is reasonable to

assume, however, that the life history of the fungus on *Myrica* and *Salix* does not differ essentially from that on its *Acer* hosts.

The ascospores are discharged in great numbers from the mature apothecia. It is a common experience when removing dead grass or leaves in collecting these apothecia to observe the little white puffs of spores shot forth from the uncovered cups. Caught by air currents, the ascospores are carried upward through the trees, some of them lodging on the exposed anthers of the staminate flowers. During the period when these spores are being discharged, the air is usually moist from frequent rains, so that the humidity of the air and the moisture on the flowers are both very favorable to the dissemination and germination of the spores.

The junior author's experiments indicate that moisture on the flowers for a period of at least twenty-four hours is necessary to insure germination of the spores and penetration of the germ tubes into the anthers. After seventy-two hours of favorable conditions practically all of the spores will have germinated and their germ tubes will have entered the tissues of the flowers.

It appears from our observations that in the male flowers the stamens only are susceptible to invasion by the fungus. How invasion of the female inflorescence occurs is not known. Spores which were observed to have germinated on the bud scales or on the calyx of the flower were not observed to have penetrated the tissues of these organs. Invasion may occur either through the anthers or through the filaments of the stamens. The germinating ascospore usually sends a penetration tube from one end directly through the wall of the epidermal cell on which it is lying (FIG. 15). Sometimes this penetration tube is markedly constricted (FIG. 16), but in other cases there is little or no constriction (FIG. 17). The mycelium spreads intercellularly within the tissues, branches freely and is at first relatively large in diameter, the segments being more or less swollen (FIG. 19). Secondary hyphae are uniform in diameter and densely interwoven.

The mycelium spreads rapidly throughout the stamens and into the tissues of the calyx, pedicels, and out into the bud scales which form a cup-like structure about the cluster of flowers (FIG. 3). These flower clusters surrounded by the bud scales drop from the trees to the moist ground. Here the mycelium rapidly invades all



the tissues of this detached flower cluster, converting it into a stromatized mummy (FIG. 1, 3, 4). The cells of the floral parts, as well as those of the bud scales, are largely disorganized and destroyed, being replaced by a dense stroma of fungous mycelium. Remnants of host cells are to be found in this stroma. These stromatized floral clusters retain, more or less, their natural form. The outer layer of hyphae, which occupies the epidermal cells, becomes dark-colored, forming a true rind, while within the densely interwoven, thick-walled hyphae form a typical white medulla.

This stromatized flower cluster lies on the ground through the winter. In the early spring one to several apothecial fundaments may be observed arising from any part of the mummy (FIG. 1, 3, 4). Microconidia are produced by the fungus in pure culture, and almost certainly appear in abundance in nature but have not yet been observed by the writers. They doubtless function in the fertilization of the apothecial fundaments as is known to be the case in *Sclerotinia Gladioli*, as described by Drayton (1932, 1934a, 1934b).

There is no evidence that this fungus has any true conidial stage, and this, together with its characters in culture, clearly places it in the genus *Ciboria*.

#### NOTES

1. The only 4-spored species with which *C. acerina* might be confused, as far as the writers have discovered, is *Peziza incondita* Ellis (N. A. Fungi No. 391), another 4-spored species (Ellis 1881, Saccardo 1889). A critical examination of the type material of *P. incondita* shows clearly that our species is quite distinct. The apothecia of *P. incondita* arise from a distinct, flattened, rugose sclerotium, not from a stromatized inflorescence as is the case with *C. acerina*. The ascospores are distinctly smaller than those of *C. acerina*. All collections of *Peziza incondita* which we have seen were taken during late June or early July, while apothecia of *C. acerina* mature during April and the early part of May. The specimen in the Durand Collection No. 4561, labeled *Peziza gracilipes* var. *tetraspora* Ellis, is presumably a part of the specimen now in The New York Botanical Garden Herbarium enclosed in a separate packet with one of Ellis' collections of *P. gracilipes* of

June 25, 1875, and which bears the label, "*Peziza gracilipes* Cooke var. *tetraspora* mihi" in Ellis' hand-writing. A note on the packet made at a later date, presumably by Ellis, indicates that this is *Peziza incondita* Ellis. Examination of the specimen confirms this. This variety name has never appeared in the literature as far as the writers can discover.

While no special attempt has been made to obtain the apothecial stage in pure culture, apothecia appeared once in an isolate from *Myrica Gale* (Herb. Spec. No. 15791) growing on potato dextrose agar slant (FIG. 6); and again from another isolate in a petri dish culture on the same medium (FIG. 11). Spore shootings made on potato dextrose agar, from apothecia collected April 18, 1927, were transferred to test tube slants on April 22, 1927. On January 7, 1928, a cluster of apothecial fundaments were observed in this culture arising from stromata formed at the center of the planting. The agar bearing these fundaments was removed and put on moist filter paper in a moist chamber; the moist chamber was then placed in a well-lighted cool greenhouse. By June 20, 1928, many apothecia with long slender stipes had developed and matured (FIG. 6). The asci were typically 4-spored.

The senior author has made three collections (Nos. 15604, 15790, and 25103) of an 8-spored species on the male inflorescence of *Acer rubrum* L. on April 18, 1927, at McLean, New York, May 3, 1927, and May 11, 1928, at Malloryville, New York, respectively. This form differs from *C. acerina* not only as to number of spores in the ascus, but also in the smaller size of the ascospores, in the darker color of the cups, and in the character of the growth on potato dextrose agar (FIG. 12). In view of these marked differences, it can scarcely be regarded as an 8-spored form of *C. acerina*. The two collections of this form are not sufficient to warrant us in describing a new species at this time. It does seem desirable, however, to record the occurrence of an 8-spored form occurring with *C. acerina* on *Acer rubrum* in this region.

The striking difference in cultural characters of the isolates of *C. acerina* from *A. saccharinum* in comparison with those from the other hosts raises at once the question whether we may not here be dealing with two distinct species in the 4-spored forms. Since we have detected no other significant morphological differences among

them the cultural differences alone do not appear to warrant the establishment of more than one species. Whether or not these cultural characters are correlated with biologic specialization of the forms on the different host plants remains to be determined.

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**Ellis, J. B.** *Peziza incondita*. In New Species of North American Fungi. Torrey Club Bull. **8**: 73-74. 1881.  
**Saccardo, P. A.** *Sclerotinia incondita*. In Syll. Fung. **8**: 200. 1889.

#### EXPLANATION OF FIGURES

Fig. 1. A collection of apothecia on overwintered male inflorescences of *A. saccharinum* in a petri dish. 21961. Around the petri dish female inflorescences bearing apothecia. 25247. Natural size.

Fig. 2. Apothecia on overwintered male inflorescences of *A. saccharinum* as they appear on the ground among dead grass and leaf debris. Natural size. 21961.

Fig. 3. Apothecia on overwintered inflorescences of *A. rubrum* together with blossom clusters taken from the trees at the time the apothecia were collected. Natural size. 15153.

Fig. 4. Apothecia on overwintered male catkins of *Myrica Gale* with flowering catkins taken from the branches at the same time. Natural size. 15152.

Fig. 5. Apothecia on overwintered catkins of *Salix discolor*. Natural size. 17469.

Fig. 6. Apothecia developed on potato agar slant by isolate from *Myrica Gale*. Natural size. 15791.

Plantings of ascospore isolates on potato dextrose agar at room temperature. Reduced  $\frac{1}{2}$ .

Fig. 7. Isolate from *A. saccharinum* about 25 days old. 23397.

Fig. 8. Isolate from *S. discolor* about 20 days old. 16703.

Fig. 9. Isolate from *A. rubrum* about 14 days old; stromatic crust not yet formed; aerial mycelium still white. 15153.

Fig. 10. Isolate from *A. rubrum* about 20 days old. 16191.

Fig. 11. Isolate from *Myrica Gale* about 20 days old. 15152. Note the apothecium growing from the margin of the lower left planting.

Fig. 12. Isolate from 8-spored unnamed species on *A. rubrum* about 20 days old. 15604.

All figures magnified approximately 900 times.

Fig. 13. Asci, paraphyses and ascospores of *Ciboria acerina* from type material.

Fig. 14. Ascospore germinating and penetrating an epidermal cell of the stamen filament of *A. rubrum* 24 hours after artificial inoculation, surface view.

Fig. 15. Same as fig. 14 except showing two germinating spores in different stages of penetration in sectional view.

Fig. 16. Same as fig. 15, showing penetration and beginning of mycelial invasion of subepidermal tissues of the stamen filament.

Fig. 17. Penetration and invasion of tissues of the stamen filament of *A. rubrum*, 72 hours after artificial inoculation.

Fig. 18. Ascospore germination, penetration and invasion of tissues of the filament of *A. saccharinum*. Natural infection.

Fig. 19. Same as fig. 18, but showing more extensive invasion of the tissues of the filament; the large irregular and closely septate mycelium produced in the early stages of tissue invasion.

## CULTURAL LIFE HISTORIES OF MELANCONIS AND PSEUDOVALSA. II<sup>1</sup>

LEWIS E. WEHMEYER

(WITH 5 FIGURES)

The genera *Melanconis* and *Pseudovalsa* represent a heterogeneous group of species whose relationships are most interesting. The limits of the family Melanconideae, in which they are placed by Winter (8, p. 764) are purely artificial. His family is based upon the type of conidial stage which is of "eigentümlicher Beschaffenheit" and consists of conidia born superficially upon a stroma. As a matter of fact, there are certain species in either *Melanconis*, *Pseudovalsa* or *Hercospora* in which the conidia are born more or less, or entirely, enclosed in locules. Von Höhnelt's Diaportheen is a much more natural grouping, but in his original tabulation of genera (3) he does not include these genera, although his other writings show that he considered them closely related. The limits of such genera (or subgenera) as *Melanconis*, *Melanconiella*, *Pseudovalsa* and *Calospora*, being based on color and septation of ascospores are likewise artificial. In fact, no single character can be used to express relationships in this group, for a consideration of the correlation of these characters soon reveals an intricate interrelated series, an unravelling of which demands a full knowledge of both stages in the life history of all species concerned. The genus *Melanconis*, for instance, is supposed to be associated with *Melanconium* conidial stages, but *M. thelebola* is associated with a *Stilbospora*, *M. modonia* and *M. perniciosa* with a *Coryneum* and *M. xanthostroma* and *M. sulphurea* with a *Myrosporium* or *Fusicoccum* conidial stage. The writer (7) has suggested that typical species of *Melanconis* are characterized by a well-developed ectostroma and the lack of blackened zones in the substratum. Many species have poorly developed ectostromata, however, and *M. thelebola* often shows marginal blackened zones,

<sup>1</sup> Papers from the Department of Botany and the Herbarium of the University of Michigan No. 580.

whereas *Melanconiella nigrospora* (*M. Meschuttii*) has a sharply outlined stromatic receptacle comparable to that found in *Herco-spora*. A segregation of such variants as new genera, before a thorough consideration of this group of species as a whole, has merely added to the confusion. Similar examples could be advanced in the genus *Pseudovalsa*. It is believed, therefore, that information as to the structure and conidial connections of such atypical and of additional species will aid greatly in illuminating these relationships and help in the organization of more naturally related groups.

***Melanconis pallida* (Rehm) comb. nov.**

This species was considered as new until an examination was made of the type collection of *Melanconiella pallida* Rehm, kindly sent by John Dearness. This was identical with material collected several times about Ann Arbor and once near Boxford, Massachusetts. It forms rounded or elongate swollen pustules (FIG. 1), commonly in confluent longitudinal series, on the surface of hickory twigs and is usually accompanied by a *Melanconium* stage (FIG. 1) with more widely erumpent and more angular pustules exposing a granular black spore mass. The ascospores of this species are sometimes irregular in shape, one cell being larger than the other (FIG. 3: 4). In one collection, from Ann Arbor, some perithecia showed a majority of one-celled ascospores, measuring  $18-24 \times 12.5-13.5 \mu$ . A single ascus may contain only one-celled or both one- and two-celled spores (FIG. 3: 3). When found, these spores were too old to investigate culturally, but they seem to be the result of the failure of the cross-wall to be laid down.

Ascospores from a collection made near Brighton, Michigan, on May 23, 1935, were sprayed onto Leonian's agar on October 10, 1935. Germination was slow and it was not until after four days that appreciable germ tubes were visible and single spore isolations could be made. The spores swelled somewhat, measuring  $42-45 \times 15-20 \mu$  upon germination. The spore wall was ruptured and one or several irregular masses of protoplasm emerged. From these several thick irregular germ hyphae,  $3.5-6.5 \mu$  in diameter, branched out and soon became septate. A number of these germ

masses from each spore gave rise to a densely branching growth of brownish hyphae about the spore. Growth on oatmeal agar was extremely slow, producing a colony only 1-2 cm. in diameter

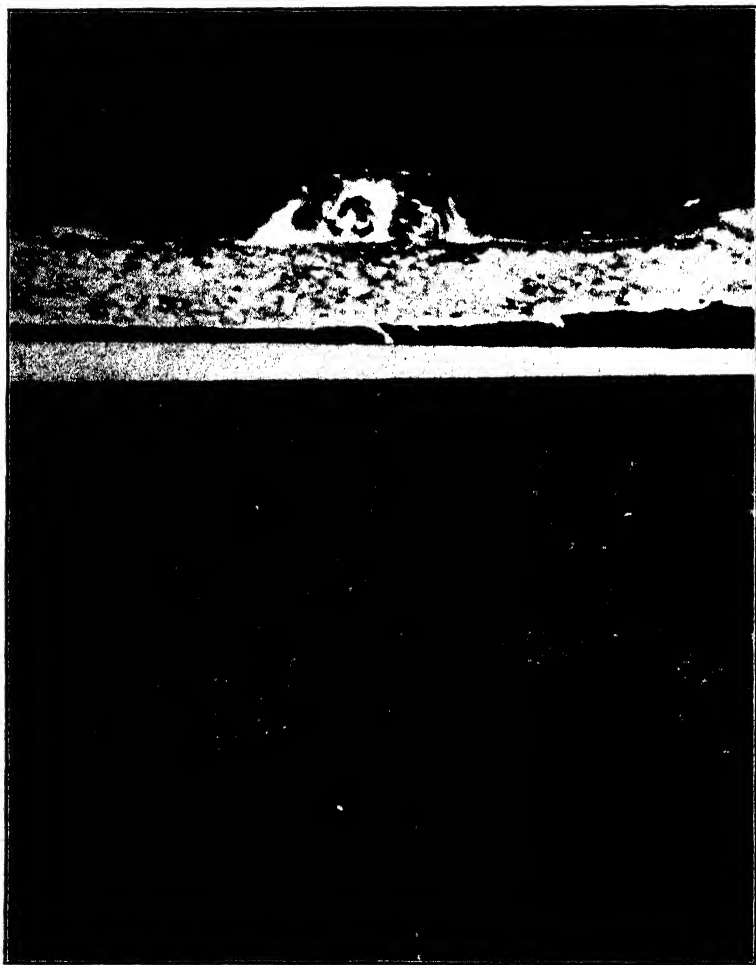


FIG. 1. *Melanconis pallida* Rehm: Radial section of perithecial stroma, above, and surface view of perithecial stroma and conidial stroma (*Melanconium intermedium* Peck), below. ( $\times 20$ )

after two weeks growth. There were usually no superficial hyphae formed, but merely a deep yellow-brown discoloration of the medium from the submerged growth. In only one tube was there a

faint surface felt of olive-green hyphae in which a few tuberculate stromata were found. Conidia, of the same type as found on twigs were present in these stromata.

Inoculations onto autoclaved twigs of *Carya ovata* also gave a very slow growth with the formation of superficial grayish tuberculate stromata from which black watery spore masses were extruded. On one twig, more normal, imbedded, erumpent stromata with similar spore horns were produced. In this case the conidial stromata (FIG. 3: 1) were in the bark, entirely enclosed and entostromatic, but in nature they are often ectostromatic and on the bark surface. The conidia arose as the swollen tips of stout conidiophore hyphae lining the margin of numerous irregular cavities which soon coalesced, leaving an irregular mass of conidia lying within the stroma, without any definite marginal wall. The conidia (FIG. 3: 2) were subspheric to ovoid or oblong-cylindric, often with a flattened apiculus at the point of attachment, and measured  $18-26.5 \times 13.3-16.5 \mu$ . The contents of the freshly formed conidium was coarsely granular and quite bright green giving an olive or greenish-brown color to the spore. The mature conidia were dark brown. No second type of conidium was seen.

Inasmuch as this species often occurs on rather freshly cut or killed branches, attempts were made to inoculate living *Carya* twigs which had been surface sterilized with mercuric bichloride, thoroughly washed in sterile water and placed in sterile test tubes. This treatment prevented surface growth of *Penicillia* and the like, but did not kill the twigs which continued to develop sprouts from their lateral buds. No infection with the *Melanconis* was obtained in any case, although a *Sphaeropsis* and several other fungi developed on the twigs. These were apparently present within the twigs when collected. This indicates that this species is not an active parasite but does not preclude its attacking weakened or freshly cut stems.

This species belongs to a group with grayish or greenish ectostromata and a *Melanconium* conidial stage such as *M. juglandinis*. This species shows an extreme condition of entostromatic development about the perithecia which, here, causes a pulvinate swelling on the surface. It also differs from other members of the group in the slight ectostromatic development which results in



a closely adherent periderm and a barely erumpent disc in the perithecial stromata. In the conidial stage, instead of open cavities on the flanks of an ectostroma, the stromatic development is either upon or within the bark cortex and is almost entirely used up in conidial formation, leaving a large mass of spores in an irregularly exposed cavity with very little stromatic base (FIG. 3: 1). The conidia commonly found associated with the perithecia in nature are similar to those obtained in culture and measure  $18-26.5 \times 13-16.5 \mu$ . This conidial stage<sup>2</sup> is the same as the *Melanconium intermedium* of Peck. Ellis' N. Am. Fungi 3471 of *M. intermedium* on *Acer*, although given as "fide Peck," is not this species. The spores of this collection are more ovoid to pyriform and larger, measuring  $21-31.5 \times 18-22 \mu$ . The type material of *M. intermedium* on hickory (N. Y. State Mus. Herb.; Buffalo, Jan. 16, G. W. Clinton and Greenbush, April, C. H. Peck), however, is typical of the *Melanconium* associated with *M. pallida*. In a letter to the writer, Dr. Dearness says, concerning the type of *M. pallida*, "I had carried this for a year as *Melanconiella larga*. Dr. Rehm would have adopted this name had he not accepted its relationship to *Melanconium pallidum*." In the original description of *M. pallida* (5, p. 397), Rehm states, "Huc pertinet: *Melanconium pallidum* Peck conidiis oblongis obtusis, 1-cellularibus, subfuscis,  $12-15 \times 5-6 \mu$ ." The type collection of *Melanconiella pallida* shows two species of *Melanconium* on the same twigs. One of these, associated with the perithecial stromata, is *M. intermedium* Peck. The second, forming smaller, more conic, clustered pustules toward the end of one of the twigs, has light brown, oblong to elliptic conidia, measuring  $11.5-18 \times 5-6 \mu$  and is *Melanconium gracile* Ellis & Ever. as represented in Ellis N. Am. Fungi 2864. This is apparently what Rehm took for *M. pallidum*. The true *M. pallidum*<sup>3</sup> as shown by Peck's (4, p. 49) description and figures and by Ellis N. Am. Fungi 959, has granular hyaline spores which are inaequilateral to curved and bear no resemblance to those found on Dearness' type material. It is barely possible that

<sup>2</sup> Ellis' N. Am. Fungi 120 of *Melanconium magnum* (Grev.) Berk. is also this species, but this binomial has probably been used for a number of *Melanconium* spp. on a variety of hosts.

<sup>3</sup> This species has been placed in the genus *Discosporium*, as *D. pallidum* (Peck) Höhn, by von Höhnelt (Sitz.-ber. Akad. Wien. 125: 100).

*Melanconium pallidum* may represent the beta conidial stage of *Melanconis pallida*, but there is no evidence, as yet, for this. This association of several species of *Melanconium* on the same twig

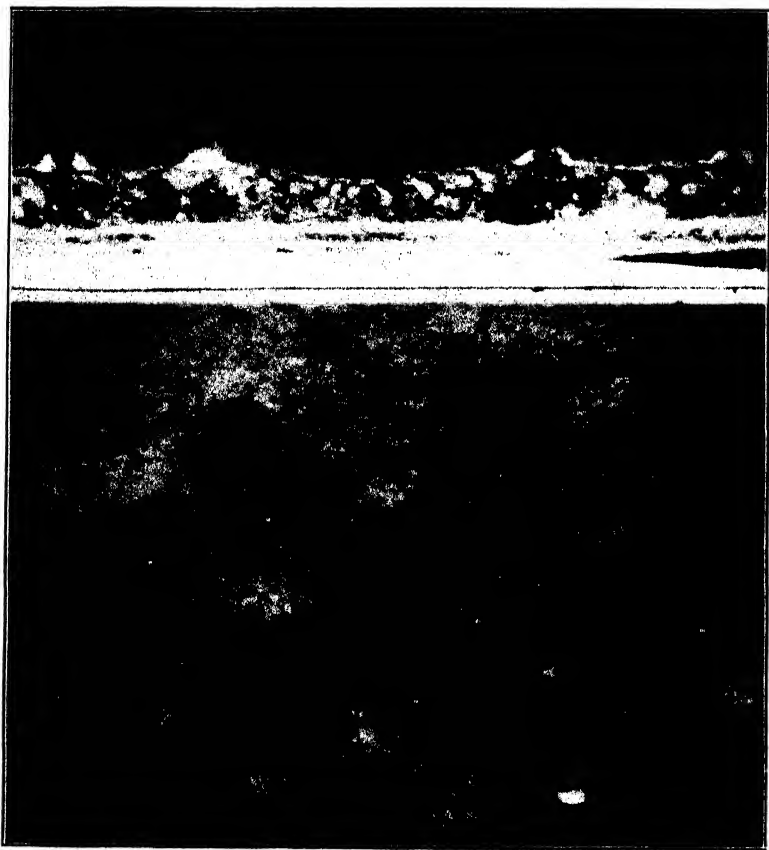


FIG. 2. *Melanconis apocrypta* Ellis: Radial section (above) and surface view (below) of perithecial stromata. ( $\times 20$ )

with this *Melanconis* again demonstrates the errors arising from life history connections based on association alone.

#### MELANCONIS APOCRYPTA Ellis

Material of *Melanconis apocrypta* Ellis was collected on *Populus* sp., at Upper Brookside, near Truro, Nova Scotia, on July 9, 1935. It was found on a recent windfall and occurred as flat,

papillate, yellowish pustules (FIG. 2), 0.3–0.8 mm. in diameter and thickly scattered over wide areas of the twigs and limbs. These pustules are faintly outlined by a darkened zone and have a minute central erumpent disc containing the convergent erumpent ostioles. The ectostroma itself is white to yellowish, flattened hemispheric and with the perithecia circinnate beneath. The ascospores (FIG. 3: 7) are hyaline at first, then brown and  $23\text{--}33 \times 11\text{--}14 \mu$ . As the ascus walls dissolve in water, the periplasm pinches off between the spores, often leaving a gelatinous envelope about the spores.

Ascospores from this material were sprayed onto Leonian's agar on October 23. No germination occurred during the first twenty-four hours, but after forty-eight hours a few spores were found germinating slowly. The spores swelled slightly, measuring  $36 \times 18\text{--}19 \mu$ , and pushed out, usually, a single germ tube about  $6.5 \mu$  in diameter.

Growth on oatmeal agar was rather slow, a colony reaching a diameter of 1–1.5 cm. in ten days. Early growth was barely visible to the eye as a pale red brown superficial mycelium which darkened with age becoming dark red-brown to black. In these blackened areas, portions of the hyphae swell to form large spherical or irregular chlamydospore-like cells (FIG. 3: 9) which may be either terminal or intercalary. The walls of these cells and adjacent hyphae become dark brown. The chlamydospore cells become filled with this pigment which diffuses into the surrounding agar forming a dark halo about them. In cultures two to three months of age, a cottony superficial growth of mycelium and a few small pulvinate stromata appeared. In some of these stromata, masses of one-celled brown conidia were formed. These conidia (FIG. 3: 8d) were irregular in shape, ovoid to ellipsoid-clavate, measured  $15\text{--}28 \times 6.5\text{--}10 \mu$  and appeared to be abnormal in their development.

Growth on autoclaved twigs of *Populus deltoides* was also comparatively slow. In moist cultures a large amount of white cottony superficial growth occurred, but as the tubes dried out, or on those twigs transferred to large damp chambers, more normal immersed stromata were formed. The pale yellowish ectostromata were such as found in nature, but larger (1–4 mm. in diameter), and were

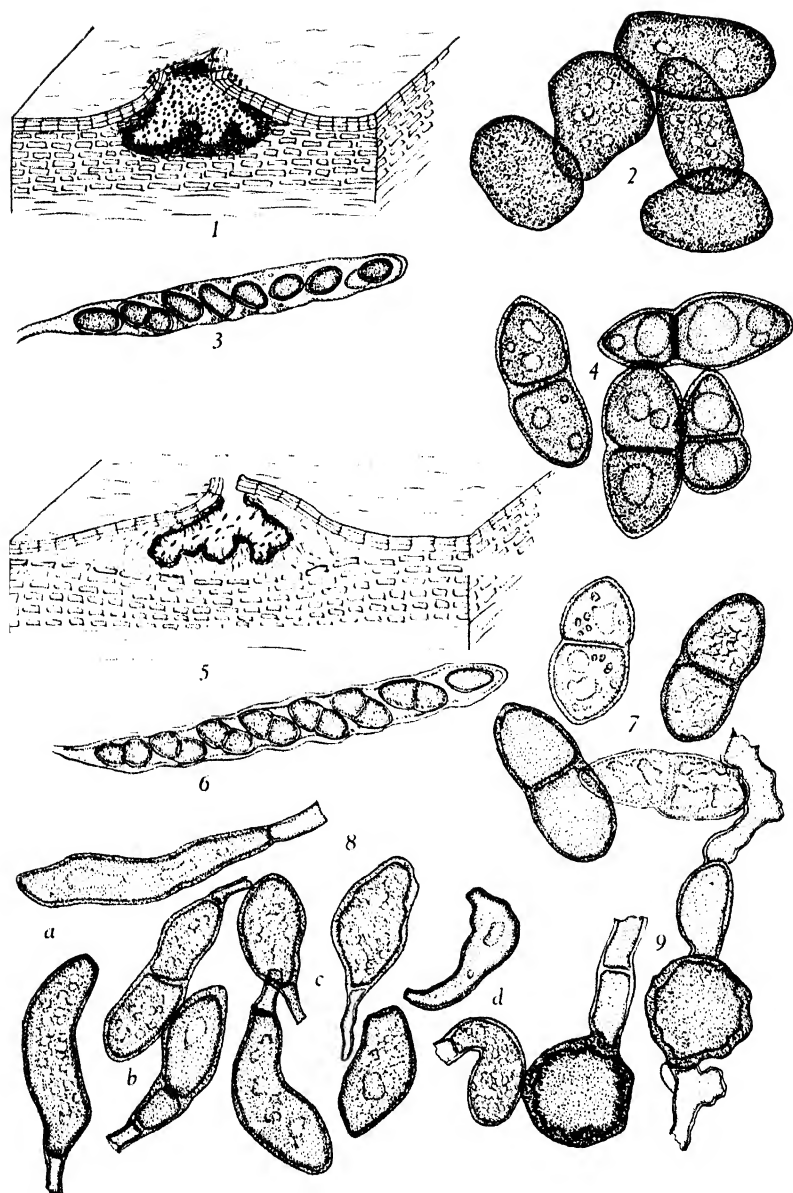


FIG. 3. 1-4 *Melanconis pallida* Rehm, 5-9 *Melanconis apocrypta* Peck: 1, vertical section of conidial stroma (*Melanconium intermedium* Peck); 2, conidia; 3, ascus containing both one-celled and two-celled ascospores; 4, ascospores; 5, vertical section of conidial stroma; 6, ascus with ascospores; 7, ascospores; 8, conidia: *a* elongate clavate, *b* two celled, *c* short ellipsoid forms produced on twig cultures, *d* irregular forms produced on agar cultures; 9, chlamydospore-like bodies formed in agar cultures.

composed of hyaline prosenchymatous hyphae,  $1.5-4\ \mu$  in diameter. The conidial stromata (FIG. 3: 5) were up to 1 mm. in thickness and in these one or two fertile areas arose, outlined by a slightly differentiated, yellow-brown, wall-like zone. These locules were usually entirely enclosed, at least at first, and the conidia were formed as clavate outgrowths of the apex of thick conidiophore hyphae and were cut off by cross walls at various levels in the fruiting area so that a compact mass of spores rather than a clear-cut hymenium resulted. The conidia (FIG. 3: 8) were at first hyaline, but soon became yellow to olive-brown with a granular content. They were quite variable in size and shape being ovoid or fusoid-ellipsoid (FIG. 3: 8c) to elongate-clavate (FIG. 3: 8a), straight to variously bent or curved and often giving the impression of abnormality as in the case of the conidia formed on agar. They were mostly one-celled, but quite a few two-celled conidia (FIG. 3: 8b) could also be found. The ellipsoid spores measured  $15-25 \times 8.5-10\ \mu$ , whereas the elongate clavate forms ran  $29-45 \times 8.5-11.5\ \mu$ .

Perithecial primordia were sometimes observed beneath these stromata in an entostromatic development in the bark cortex but were much more abundant beneath other sterile ectostromata which were smaller and undoubtedly represented the immature discs of perithecial pustules.

Ellis (1, p. 194), in his original description of this species, suggests *Melanconium populinum* Peck as the imperfect stage. An examination of the type material of *M. populinum* (N. Y. State Mus. Herb. ex Ellis No. 3637) reveals rather large angular pustulate ruptures caused by the growth of whitish ectostromata up to 1.5 mm. in diameter, which in turn contain large lobed cavities which are often entirely enclosed at first and resemble very closely those obtained in culture. The conidia of *M. populinum*, however, are oblong-ellipsoid and quite regular in shape, usually with a darkened basal scar at the point of attachment. These conidia are pale brown, becoming darker, one-celled, and  $13-16.5 \times 5.5-6.5\ \mu$ . It is possible that the conidia obtained in culture represent an abnormal condition of the conidia of *M. populinum*, but until there is further substantiation of this possibility it would

seem better not to apply this name to the conidial stage of *Melanconis apocrypta*.

The specific relationships of *Melanconis apocrypta* are not clear. It has the light colored ectostroma of the *Melanconis marginalis*-*M. Alni*-*M. stilbostoma* group but differs in the brown ascospores and conidia, the slight development of the ectostromatic disc, and the enclosed character of the conidial locules. These enclosed locules, together with the tendency for the conidia to become long clavate and two-celled suggest a transition toward the species with a *Stilbospora* conidial stage, as has been reported for *Melanconis thelebola*. *M. thelebola*, however, has light colored and appendaged spores. Further knowledge of conidial connections of other species may clear up these relationships.

#### PSEUDOVALSA STYLOSPORA Ellis & Ever.

*Pseudovalsa stylospora* is an interesting species occurring as numerous small pustulate ruptures (FIG. 4), 1-2 mm. in diameter, on the surface of maple limbs. The small white ectostromatic disc formed on the bark surface causes a radiate rupture of the periderm which may fall away in age. The perithecia arise in the unaltered or slightly entostromatic bark cortex beneath. The ostiolar necks penetrate through the small ectostroma and almost obliterate it, being erumpent as a small fascicle of short or slightly elongate ostioles. The asci lie free, in a mass, within the perithecium with a few evanescent bandlike paraphyses. When young, the asci are rather elongate-clavate,  $80-85 \times 14-15 \mu$  and the spores are then biseriate, fusoid, one-celled and hyaline. The spores (FIG. 5: 2) soon become elongate, oblong-ellipsoid, three-celled and finally pale yellow-brown. The asci meanwhile become broad-clavate (FIG. 5: 4) or saclike with a thickened apex and measure  $53-66 \times 20-28 \mu$ . The spores in these asci are massed together, are more or less constricted at the septa, commonly show a small caplike appendage at each end and are  $22-40 \times 9-12 \mu$ .

The general appearance and stromatic configuration of this species suggests certain species of *Cryptodiaporthe* as *C. densissima* and *C. myinda*, also occurring on maple. The small but distinct, white ectostroma recalls *C. galericulata*, in which species the spores may also become brown at full maturity and which, it seems, has

been described under other names (*M. leucostroma*) in the genus *Melanconis*. The biseriate arrangement of the spores in the elongate young ascus is a condition commonly found in *Melanconis* and *Cryptodiaporthe*, whereas the massing of the spores in the saclike

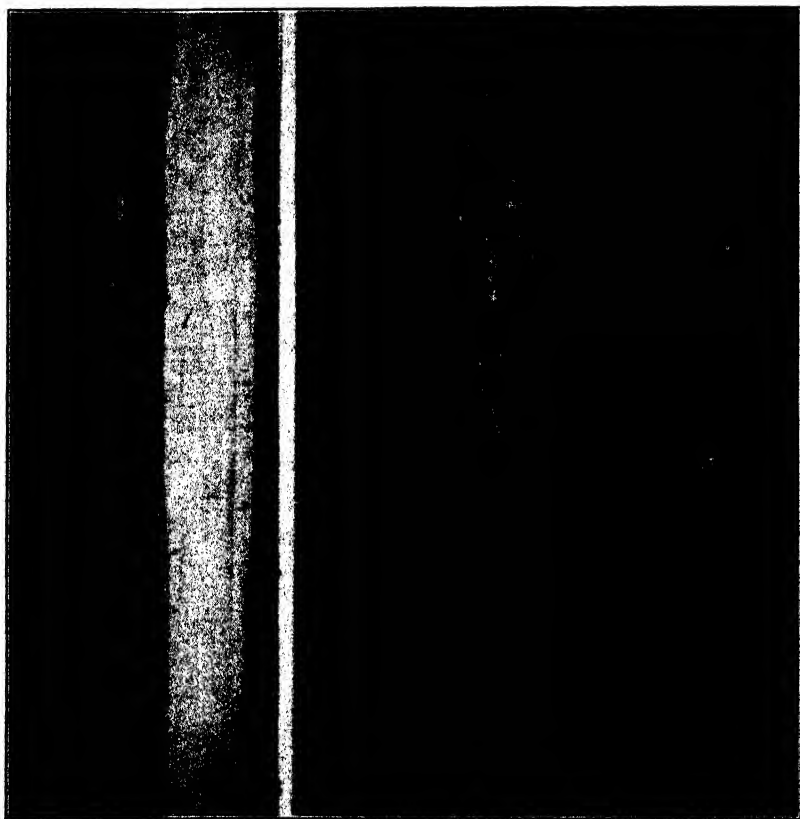


FIG. 4. *Pseudovalsa stylospora* Ellis & Ever.: Radial section (left) and surface view (right) of perithecial stromata. ( $\times 20$ )

mature ascus is commonly found in *Pseudovalsa*. The bearing of the conidial stage on these relationships will be considered later.

Sprays of ascospores of this species were first made on August 5, 1926, from twigs of *Acer spicatum* collected at Wolfville, Nova Scotia, the preceding June. A second isolation was made on October 10, 1934, from *Acer spicatum* collected at Seventh Lake, N. Y., the previous August. The results were similar in both

cases. Germination (FIG. 5: 3) occurred from twenty-four to forty-eight hours after the spores were sprayed onto agar. These spores were mostly hyaline, but some pale brown spores were seen germinating. A few spores which were still one-celled germinated. Only those spores with a granular content, and not those with a homogeneous protoplast, were able to germinate. The germinating spores measured  $31-37 \times 11-14 \mu$  and put forth from one to four germ tubes, some five microns in diameter.

Growth was very slow on nutrient agar but more rapid on oat-meal agar. The advancing margins of the colonies were white, but soon turned grayish in the older portions. At the center of older cultures, numerous grayish pulvinate stromata, 1-2.5 mm. in diameter, appeared, from which pinkish to yellowish-brown masses of conidia were extruded. The center of these stromata contained a single chamber lined by the conidial hymenium. These conidia (FIG. 5: 5f) were oblong-ellipsoid to long-cylindric, straight or often slightly curved or bent at one end, one- to usually four-celled, hyaline and  $17-44 \times 5-6.5 \mu$ .

In the case of both isolations, twigs of *Acer saccharum* were inoculated from single spore cultures and after two to three weeks small pustulate swellings appeared on these twigs. The spore horns from these pustules were grayish to yellow-brown when moist to almost black when dry.

The formation of the stromata on *Acer* (FIG. 5: 1) was instructive. The ectostroma arises on the surface of the bark cortex, just beneath the periderm as a thin layer, some  $20 \mu$  thick, composed of fine hyaline hyphae, and may extend for some distance. Where conidial locules arise, this tissue increases greatly in thickness and a cavity arises in the center as a result of spore formation from free hyphal tips in this region. The pycnidium may remain flattened or increase in thickness and become spherical. A definite wall of pseudoparenchyma cells with dark olive-brown walls is formed on the surface. This wall is more strongly developed below than above. As a result the periderm may at times be thrown back with the upper wall adhering to it and more or less exposing the spore bearing cavity. The conidia (FIG. 5: 5e) in these cavities were similar to those formed on agar but not so commonly bent at one end, more constantly four-celled and meas-



ured  $33-50 \times 5-6.5 \mu$ . They are borne upon a hymenium of short stout cylindric conidiophores.

Entostromata were also strongly developed upon these twigs, but they always arose at a depth of two to three cell layers within the bark cortex and never produced pycnidia. They consisted of a proliferation of fine hyaline hyphae intermixed with the remains

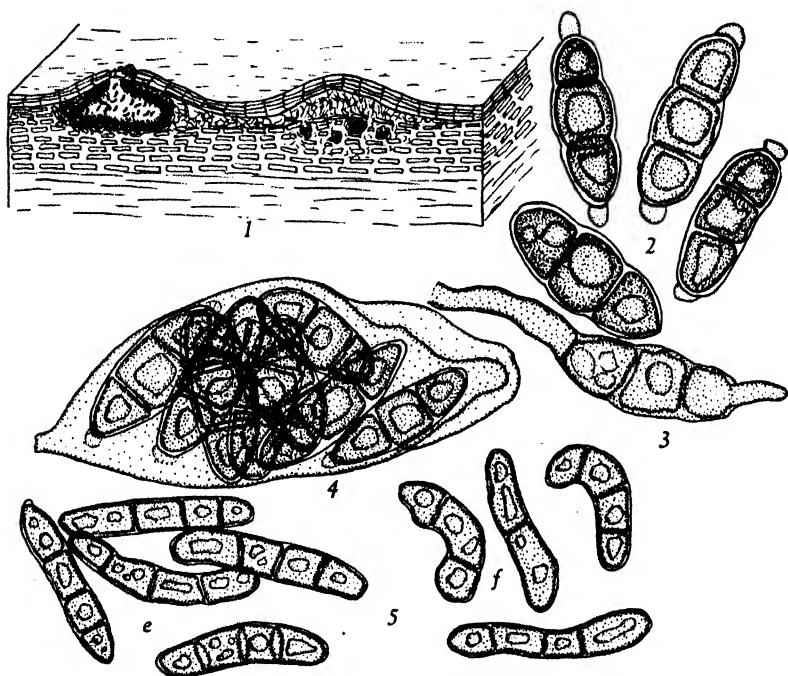


FIG. 5. *Pseudovalsa stylospora* Ellis & Ever.: 1, vertical section of conidial and young perithecial stromata; 2, ascospores; 3, germinating ascospore; 4, ascus with ascospores; 5, conidia: *e* as formed on twigs of *Acer saccharum* in culture, *f* as formed in agar cultures.

of bark cortex cells. Perithecial initials consisting of spherical knots of coiled hyphae were frequently found in these entostromata.

Ellis (2, p. 223), in his original description of this species, mentions "pycnidia central bearing 3-septate, hyaline stylospores,  $40-55 \times 10-12 \mu$  on short basidia" which are undoubtedly the same as those obtained in culture, even though he gives the diameter as twice as great.

In the light of what has been said regarding the relationships of the perithecial stroma, this conidial stage is of interest. The conidia here are hyaline and formed within an enclosed locule, which is characteristic of *Diaporthe* and certain species of *Cryptodiaporthe*, rather than colored and on the surface of the stroma as is supposed to be the case in most species of *Melanconis* and *Pseudovalsa*. They are, however, many-septate as in *Pseudovalsa*. The genus *Pseudovalsa*, it is the writer's belief, will fall into several species groups in which the conidial stage will be correlated with certain ascospore characters. Conidial connections of certain species with caplike appendages, as *P. aucta* and *P. macrosperma* would be of interest in this respect. Tulasne (6, *pl. 14, fig. 13-23*), for instance, illustrates a somewhat similar pycnidial stage for the latter species but with dark colored, four-celled conidia. *P. stylospora* may represent a type intermediate between certain appendaged *Cryptodiaporthes* and certain brown spored species of *Pseudovalsa*.

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## RHIZOPUS ELEGANS EIDAM<sup>1</sup>

LEWIS B. LOCKWOOD

In 1820, Ehrenberg (4) established a new genus *Rhizopus*, based upon a fungus *R. nigricans*, which he had previously described as *Mucor stolonifer*. The new genus *Rhizopus* was characterized by the presence of stolons, which were lacking in *Mucor*. While it is not possible definitely to identify any species now known with *R. nigricans* Ehrenberg, usage has associated this name with a large achlamydosporic form with spheric or subspheric, collapsing columellae, rough sporangial walls, and angular, striate spores, 8–15  $\mu$  in diameter.

In 1886, Eidam (5) described a new species of *Rhizopus*, *R. elegans*, which has smooth rounded spores, but is similar to *R. nigricans* in most other characteristics. He made no reference to the apophysis, which is assumed to be lacking. Schostakowitsch (13) established the genus *Actinomucor*, based upon *A. repens* Schostak., for a stoloniferous *Mucor* in which the apophysis was also lacking. Lendner (8) described a *Mucor botryoides* Lendner in 1910. Reinhardt (11), after examining Lendner's culture, reported the presence of stolons in *M. botryoides*. He concluded that *R. elegans* Eidam and *A. repens* Schostak. were synonyms of *M. botryoides* Lendner, and retained the latter name. Bainier (1) in 1903 described *Glomerula repens*. Lendner (7) changed this to *Mucor glomerula* (Bainier) Lendner, while Saccardo (12) in 1912 called the organism *Mucor repens* (Bainier) Sacc. and Trot. Pišpek (10) in 1929 described *Mucor Cunninghamelloides*, from the soil of Yugoslavia. Harz (6) described in 1871 *M. corymbosus*, which Zycha (15) considered a questionable synonym of *Actinomucor repens*. Zycha (15) retained the name *Actinomucor repens*, and gave as synonyms *R. elegans* Eidam, *M. botryoides* Lendner, *Glomerula repens* Bainier, *Mucor glomerula* (Bainier)

<sup>1</sup> 263d Contribution from the Industrial Farm Products Research Division, Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D. C.

Lendner, and *Mucor Cunninghamelloides* Pišpek, and *M. corymbosus* Harz?. He considered *Actinomucor* to be transitional between *Mucor* and the Thamnidaceae. The genus *Actinomucor* is monotypic.

The occurrence of stolons is deemed an adequate basis for rejection of the genus *Mucor* for this species. The problem of the systematic position of this species now resolves itself into the question of the value of the apophysis for separation of the two genera. The apophysis is a swelling at the base of the sporangium. Accordingly, counts of sporangia with and without apophyses were made. In *R. nigricans* Ehrenb. 747, apophyses were lacking in 33.8 per cent of the sporangia; in *R. reflexus* Bainier 838, apophyses were lacking in 21.1 per cent of the sporangia, and there were no apophyses beneath 9 per cent of the sporangia of *R. fusiformis* Dawson and Povah 916. In *R. pygmaeus* Naumov, the apophysis is usually lacking, but *R. pygmaeus* is so close to *R. microsporus* van Tieghem that separation is difficult on other bases. Further, the writer has often observed sporangia of *R. liquefaciens* Yamazaki with which there were no apophyses.

Several cultures of *R. elegans* have been studied. In these cultures, the apophysis is uniformly lacking. The colony type and development of stolons is typical of that of the larger members of the genus *Rhizopus*; i.e., *R. nigricans* Ehrenb., *R. Oryzae* Went and Geerligs, and *R. reflexus* Bainier. Branching is characteristic of the center of the deep type of *Rhizopus* colony. Clusters of sporangiophores, which may be septate, arise from nodes opposite the rhizoids. Rhizoids may be poorly developed as in *R. arrhizus* Fischer, or with more extensive development as in *R. nigricans* Ehrenb. Branches of the sporangiophores arise irregularly, often suggestive of the manner of those of *M. racemosus* Fresenius, or verticillate as in *R. Artocarpi* Racib. This latter mode of branching has been described for *R. umbellatus* Smith (14), but Miss Smith's illustration and description are strongly suggestive of *Absidia*. It has been described for *R. nigricans* var. *verticillatus* Demelius (2). When the stolon does not come into contact with some solid substrate, there is irregular and slight development of rhizoids, and irregular development of sporangiophores. Sometimes in *R. elegans*, the stolon will terminate in a sporangium as in

*R. reflexoides* Philippov (9). In such cases, frequently the large sporangium at the end of the stolon will be subtended by a verticil of short branches bearing smaller sporangia. It is probably some structure such as this which caused Zycha to place *Actinomucor* intermediate between *Mucor* and the Thamnidaceae.

While making a study of the physiology of the species of the genera *Mucor* and *Rhizopus*, it was found that *Mucor hiemalis* Wehmer 522, 545, 854; *M. griseo-lilacinus* 572, 625, 701, 749, 860; *M. plumbeus* Bonorden 521; *M. racemosus* Fresenius 505; *M. zeicola* Graff 496; *M. griseo-cyanus* Hagem 502, 506, 508; *M. christianiensis* Hagem 526; *M. genevensis* Lendner 548, 462, 563; *M. coprophilus* Povah 588; *M. javanicus* Wehmer 579, 718; *M. circinelloides* van Tieghem 755, 840; *M. geophilus* Oudemans 550; *Mucor* sp. 568, 571, and 582 readily utilized  $\text{NaNO}_3$  as a source of nitrogen. *Rhizopus Artocarpi* Raciborski 640, 641, 881; *R. bovinus* van Beyma 844; *R. chinensis* 492; *R. Cohnii* Berlese and de Toni 871; *R. delemar* (Boidin) Wehmer 395; *R. elegans* Eidam 882, 883, 914; *R. formosaensis* Nakazawa 843; *R. fusiformis* Dawson and Povah 916; *R. nigricans* Ehrenberg 491, 499, 520, 538, 611, 738, 747, 821; *R. nodosus* Namyslowski 584, 585; *R. Oryzae* Went and Geerligs 394, 610, 617, 649, 660, 664, 704, 713, 720, 723, 739, 743, 778; *R. Peka I* Takeda 839; *R. pusillus* Naumov 798; *R. pygmaeus* Naumov 797; *R. reflexus* Bainier 515, 796, 838; *R. shanghaiensis* Yamazaki 913; *R. suinus* Nielsen 795, 833; *R. Triticum* Saito 488, 602, 654, and 681 were unable to utilize  $\text{NaNO}_3$  as a source of nitrogen. Bach (2) reported that *Rhizopus* was unable to utilize nitrate.

A number of times apparent late growth of *Rhizopus* occurred on  $\text{NaNO}_3$  solutions, but in all such cases the cultures were found to be contaminated with *Absidia*, *Cunninghamella*, *Syncephalastrum*, or an Hyphomycete. When the cultures were purified, no growth occurred on  $\text{NaNO}_3$ . It is probable that the contaminating organism utilized the  $\text{NaNO}_3$ , and after autolysis had set in, the *Rhizopus* began to use the nitrogen from the autolyzing mycelia.

No species of *Rhizopus* studied was able to utilize  $\text{NaNO}_3$  as a nitrogen source, while all species of *Mucor* studied utilized  $\text{NaNO}_3$  readily. The writer has successfully utilized this in the elimina-

tion of *Rhizopus* from cultures of other fungi contaminated by *Rhizopus*.

Several *Rhizopus* cultures produced large quantities of lactic acid from glucose, while no *Mucor* gave appreciable yields of lactic acid. Cultures of *R. elegans* were not able to utilize  $\text{NaNO}_3$  as a sole source of nitrogen, but when  $(\text{NH}_4)_2\text{SO}_4$  was supplied, culture No. 914 produced large quantities of lactic acid from glucose. While the last two points are of physiological nature, the writer is not inclined to offer them as basic points for use in delimiting genera and classifying species. However, it is believed that they indicate that the affinities of the organism in question are closer to *Rhizopus* than to *Mucor*.

In view of the fact that *R. elegans* has stolons, the deposition of the species in the genus *Mucor* is believed untenable. The maintenance of the genus *Actinomucor* separate from *Rhizopus* is believed undesirable because the basic character of absence of an apophysis is inadequate and unreliable. The name *Rhizopus elegans* Eidam should be maintained, the deposition of the species in the genus *Rhizopus* being based upon the morphology of the organism, supported by physiological experimentation as herein reported.

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# A CRITICAL STUDY OF THE MYCETOZOA OF LONG ISLAND

ROBERT HAGELSTEIN

The Mycetozoa or Myxomycetes are an interesting group of organisms with a unique life history. Commencing their cycle with the spores, these, with suitable conditions of moisture and temperature, will germinate into small, amoeboid bodies—true animals—which, after various transformations, fuse in great numbers to form a living slime called the plasmodium. The plasmodium moves by extending pseudopodia, feeds, and increases in size by nuclear division. It is generally admitted to be an animal. When the time comes for reproduction, the plasmodium emerges from its habitat, draws itself together, and forms fruiting bodies or spore carriers, the spores of which repeat the cycle. The fruiting bodies and spores are similar in appearance and certain physiological characters to those of the fungi. The classification of the group is based upon them as there is no differentiation in the plasmodia except size, color, and habitat. The study of the forms is confined mainly to botanists, although their position as vegetable is not established, and their earlier life history indicates a closer relationship to the animals.

It is not possible within the confines of this paper to give a complete story of the life history, morphology, physiology, and taxonomy of the Mycetozoa. For this, the reader is referred to the two excellent monographs on the subject, mentioned in the footnote,<sup>1</sup> which should be in the library of every nature student. They are complete, and nothing further is required, but they are necessary for a proper understanding of this paper, as the interpretations of species are based upon the descriptions in those monographs, and frequent references are made thereto.

<sup>1</sup> Lister, G. A Monograph of the Mycetozoa, ed. 3, xxxii, 296 p., 222 col. pl. London, British Museum, 1925. Sh. 31/6. Macbride, T. H. and Martin, G. W. The Myxomycetes, viii, 339 p., 21 pl. New York, Macmillan Co., 1934. \$6.00.



The plasmodia of the Mycetozoa inhabit decaying, vegetable material. Broadly, they may be divided into two divisions; those that live, move, feed, and grow in and on wood, logs, dead trees, etc.; and those that thrive in and on the substratum of the soil. While some species favor both habitats, the great majority are confined to one, developing their fructification on their particular habitat, and usually in close proximity to where the plasmodium emerges. There are instances where the plasmodia travel for some distance before fruiting, apparently seeking dryer places to insure perfect maturity. Our field experience indicates that where this travel is for any long distance, the food supply has been exhausted in the original habitat, and the plasmodium seeking another base and finding none, is compelled to go into fruit, to avoid desiccation and destruction. Some of the species have a preference for particular wood or leaves, but this is not general, and usually the plasmodia adapt themselves to any material available for their group, wood or the ground.

Fructification occurs when the plasmodia reach a certain size, varying with the species, and requiring a definite length of time. When this is known, the appearance may be looked for in appropriate periods or months of the season. Many species have a short period, appearing therefore several times in a season. Others fruit only once in the late season, the plasmodia vegetating through the spring and summer months. There are a few species that appear only at intervals of years, and it is probable that there the plasmodia do not transform into fruit annually. It is also known, that with the entire absence of food the plasmodia must go into fruit. With the advent of frosts and colder weather, in the late fall, the plasmodia form into hard, sclerotoid, masses, by which they survive the winter, and are revived by the warm weather and rains of early spring.

The Mycetozoa comprise about three hundred and fifty recognized species, arranged in about sixty genera. The classification is based on the varying characters of the fruiting bodies known as sporangia, plasmodiocarps and aethalia. The sporangial fructification is the most common, with sporangia of small, microscopic size, while aethalia may be six inches, or more, across. The fruiting bodies exhibit great diversity in shape and color, and of more

importance are the differences in capillitium, spores, stalks when present, and the absence or presence of lime. Many of the species have a wide range of variation, caused perhaps by differing conditions at the time of fructification as well as during the plasmodial stage. There are numerous forms intermediate between species, yet the main specific characters are very constant, and found in specimens from all parts of the world. There is an almost unbroken line of forms, merging one into the other, throughout the entire series of genera and species. It is evident that the Mycetozoa are a very young group, expressed in geologic age, and that insufficient time has passed to permit any semblance of sharp demarkation, even between genera that are sharply defined at the extremes. The evidence in favor of hybridism is neither conclusive nor disproved. Hybrids probably exist, and further study through culture methods, may show that several forms, at present regarded as species, may be hybrids; particularly so, those few that appear only after long intervals.

The fruiting bodies may be found from April to December, and sometimes later if the winter is mild, on suitable habitats with proper conditions for their development. A moist, marshy, area, well forested, and with sufficient fallen and decaying timber, makes a happy hunting ground. They may be searched for in parks, woods, back yards, or even at the seashore. Piles of lumber, straw, hay, manure, and tree trimmings, often yield many interesting species. Wherever vegetable material is in early stages of decay, they may be found; but the value declines with the decrease of the bacteria on which the plasmodia depend for food. Situations directly exposed to the heat and light of the sun, are not suitable, as there is insufficient moisture. The Mycetozoa are so beautiful, their collection so easy, and their preparation so simple, that in this age of nature study enthusiasm, more persons should avail themselves of the opportunity they offer. It is hoped that among the readers of this paper, there will be more who will undertake their study.

In the collection and study of the Mycetozoa, the best results are achieved by confining activities to a prescribed region, with intensive work there, rather than desultory collecting here and there at widely separate localities. In that way the student ac-

quires knowledge of the forms in the region, at first hand, and with the material for study in all its phases and variations, is in a better position to judge the extensions or limitations of a species. Variation is so great, that often, a number of collections must be made before a determination of the species is possible. One of them will have the salient character on which the species is based. Also, it is the variation that makes the study so fascinating.

About twelve years ago, I commenced their survey in Long Island, and have been actively assisted therein by Mr. Joseph H. Rispaud, and to some extent by two other friends, Mr. Leon J. Chabot and Mr. John D. Thomas, so that whenever the plural pronoun is used in this paper, it means that more than one of us were engaged in the collection or observation. Long Island is situated at the southeastern end of the State of New York, a part thereof, and has many natural advantages for the development of the Mycetozoa. There are many wooded kettle holes in the terminal moraine traversing the Island. The large estates, with their piles of rotting timber, that has been cut out to beautify the landscape, the forested swamps adjoining the many brooks and waterways, and the lumber yards are fertile localities. The latter, brought about by the extensive building operations in recent years, receive lumber from different parts of the world, and this often carries spores and plasmodia, some of which adapt themselves to the new environment. I do not believe, however, that the conditions here are better than elsewhere, but that the satisfactory collecting results were obtained by the intensive efforts made over a long period. During a recent visit to the Adirondack Mountains of New York State, Mr. Rispaud and I collected more than seventy-five species in four days, within a limited area. This is about the number of species that may be collected, anywhere, in a season, and were found in our first year on Long Island. The next year, yielded about the same number, certain species replacing others that were not found again. Thus it continued, year after year, the number of new collections gradually becoming smaller, so that now we are happy if we find, in a season, one or two species that we have not seen before. Of the 162 species reported in this paper, all but two or three were found in the area of Nassau County, where our most active work was

done, but the great majority were also collected in other parts of Long Island. There are still many forms that have been collected in adjacent territory, but not seen here, and it is a fair guess, that eventually two hundred species will be reported from Long Island. The work will be continued.

We are methodical in our field explorations. Driving over the beautiful roads of the Island, we are continually on the watch for auspicious spots or small units. If any are seen, they are examined for signs, and if found, the place is visited again. If the locality comes up to our expectations, it is visited repeatedly, particularly within a few days after a rainy spell, when the fruiting bodies appear abundantly in a rich spot. It is in this way that we have discovered a few areas, which are very productive, and most of our time has been spent in them with better opportunities for making extensive collections. In each of these places, one or more species have been found that have not been observed elsewhere, and also, at many other situations, rare or unusual forms have been found under less favorable natural conditions. These are visited occasionally, and at such times, when our records show that the expected form is about due to appear.

Albertson, mentioned frequently in this paper, has been, and is yet, our best, small, collecting unit. The name, for our purposes, applies to a kettle hole in the foothills of the moraine, on the I. U. Willets road, about three-quarters of a mile west from its intersection with Willis avenue, in the Village of Albertson. It is south of the road and adjoins it, directly opposite an entrance of the Shelter Rock Country Club. The ground comprises about four acres, sloping gradually to a depth of about thirty feet below the surrounding, irregularly circular, crest. The bottom is always moist, except in times of drought, but water does not accumulate, as the thin, underlying, clay layer permits constant seepage. There is no brook water flowing into the depression, but it is evident that before the construction of the road, the area of the kettle hole was larger, and water from a nearby brook may have entered it. The area is heavily forested, with fallen, decaying timber, and much underbrush. It is unoccupied, and in a wild, natural, state.

I have described the area in detail, as it is ideal for the development of the Mycetozoa, having produced one hundred and eighteen

different species during the time of our investigations, of which three have been described as new to science. It is not unusual to find from twenty-five to thirty species fruiting at one time, some of them in abundance. The ground and wood of the whole area seem to be saturated with plasmodia, the different species following successively in their fruiting as the season advances. In one year, sixteen species were taken from the same log at various periods. The immediate surrounding territory is also good, and many species have been collected within a half-mile of the hole.

The railroad trestle, close to the station at Mill Neck, crosses a swamp on both sides of a brook, which comes from the lakes on the Brokaw estate to the south. The swamp extends along the road, for a half-mile or so, and is densely covered with old trees. There are many springs, with water bubbling from the ground, which keeps the whole region wet so that hip boots are required in some parts. It was our first extensive collecting ground, and in the early years, the best, with its wild, jungle-like, conditions. We have taken from there a total of eighty-eight species, among which was *Physarum penetrans*—our only collection. There might have been more, but a few years ago the present owner started to improve the place by cutting out decaying trees, removing them and the fallen trees and underbrush, filling in wet spots, and constructing rustic bridges over the rivulets that flow into the brook. It is all very nice and comfortable, but the usefulness to us is gone. We rarely visit it now, as the remaining species are those that are common everywhere, and the old nooks and crannies, that we were wont to search with glee, are also gone.

We reside in the Village of Mineola—all of us. On the usual habitats, in back yards, unoccupied ground, or the village streets, we have found fifty-three species, four of which have not been collected elsewhere. My back yard, measuring forty by fifty feet, has produced twenty species. Truly, it may be said, that we do not know what surrounds us until we look.

In 1927, I purchased a summer cottage at Jones Beach. Immediately on occupancy, we searched the vicinity of the cottage and found many species, on sedges and grasses close to the sand, on drift wood, under bayberry bushes, and on all sorts of rubbish strewn over the beach. Fruitings of *Lycogala epidendrum* were

found on several occasions, directly on the white sand, the plasmodia arising from newspapers buried in the sand. In a number of species, the best developments have been found on this beach.

The Meadow Brook locality is the marshy ground along the wooded brook of that name, east of the Village of Roosevelt, and extending several miles. The area is now included in Meadow Brook State Park. The natural conditions there are good, and more species will be collected in time, if the improvements in progress do not destroy the habitats. *Lamproderma columbinum* occurs there, usually in abundance on mossy stumps, in the late fall.

The name Great Neck is applied to the large kettle hole at the end of the Great Neck peninsula, a stretch of land jutting into Long Island Sound, with bays on each side. The hole is deep, perhaps fifty feet, heavily forested, and with much undergrowth. At the bottom is a pool of stagnant water, and altogether the place looks uninviting. Nevertheless it is rich in Mycetozoa, and we have explored it many times, using a hunting knife to cut our way through the thickets. It is the only place on Long Island, so far as we know, where specimens of *Brefeldia maxima* may be obtained at the appropriate fruiting time.

The Deer Park forest extends for several miles on each side of the Motor Parkway, commencing about two miles from the Deer Park road. It is a beautiful forest, with many trees that are two hundred years old, or more. The forest extends far enough away from the parkway, on one side, to obliterate all noises from passing automobiles, so that it is safer to carry a compass on a cloudy day, to assure rapid return to the car, as the trails are far apart. It is the home of deer and fox, and in the fall, the *Trichiaceae* are abundant and reach a better state of perfection than in wetter situations. Many other species are found throughout the season, but the developments are far apart and require much tramping in order to locate them.

The foregoing completes mention of our principal units. There are many of lesser importance to us, and others at points remote from our homes are under investigation, and indicate prospects of becoming satisfactory. It is to them that we are turning, as the old localities are nearing exhaustion, except for the forms that appear year after year.

In the field, each collector has a pocket knife with large, sharp, blade, and a hand lens. In the car, we carry a saw, chisel, and mallet for refractory wood, or fruitings across the grain, at the ends, which cannot be removed satisfactorily with a knife. The collected specimens are placed in old cigar boxes, the bottoms of which are lined with corrugated cardboard, and pinned thereon by pins with large glass or porcelain heads, which are more comfortable than those with the smaller, metallic heads. The boxes provide safe carriage, and the bottom cardboard absorbs much of the moisture on the way home. Great care should be taken to keep all pieces of one fruiting together, and not confuse them with others. Perfectly matured material should be sought for, but this is not always available in the case of rare or unusual species, and the beginner will require a little experience to know when material is well matured, or not too far gone. It is always best to leave some of the fruiting, if of a rare or unusual species, to avoid extinction in the neighborhood. Attention may be called here to the statement, often made, that certain forms are rare generally, which is not so with many of them that we have found repeatedly. They may be rare in a particular region, but over a large territory, the infrequency of collection is more apt to be due to unfamiliarity with the form or habitat, or because of absence during the limited periods in which some species appear.

On arrival home, the specimens should be prepared at once for drying. The wet, superfluous wood and leaves should be trimmed away, and the specimens placed in large, cardboard boxes, with a quantity of the ordinary naphthaline flakes used for destroying moths and insects, care being taken to keep all fruitings separated. The boxes should be marked with the date of collection and locality, and then put away so that the material will dry out thoroughly, which may take a week or two. Conveniently thereafter, the specimens should be trimmed again, and permanently mounted in small cardboard boxes by affixing them with glue to the bottom or cover of the box, or to small pieces of cardboard with two sides turned up, which fit into the boxes and permit easy removal, if desired. Boxes, covers, and inserted cardboard should bear similar numbers so that the parts can be reconciled. It is best to assign a separate number to each fruiting, and to carry that num-

ber on all boxes and parts containing pieces of the fruiting. A neat method of storing in uniformly sized boxes, with suitable provision for duplicate material, will go far to make the entire collection more attractive in appearance. The specimens will keep well in small boxes without further attention, but larger boxes should be examined about once a year, and a small quantity of naphthaline placed therein. Specimens should always be stored in covered boxes, and never so that they are exposed to daylight for long periods, as they fade or change in color.

For the study of external characters, the specimens are examined, under a low power, in the boxes as mounted. For the capillitium and spores, all that is necessary is to place a little of both on a slide, with some water and a cover glass. It is difficult to remove air from the capillitium, and a weak solution of alcohol is sometimes preferable. For various methods, and also for the technique of making permanent mounts, the reader is referred to the Monographs previously mentioned. The method of examination in water is convenient, the spores swell rapidly, and the material is not altered in color or otherwise.

The student, in making determinations of species by transmitted light with the microscope, is advised not to attach too much importance to fine distinctions in spore color as given in the books, as the spores vary in color, in many species, in collections from the same locality. Also, color interpretations by different authors do not agree, depending evidently upon the human eye that made them, the lenses and lighting of the microscope used, and the medium in which the spores were mounted. In spores of the same species, larger ones will be darker than smaller ones, because the light passes through a greater thickness. Spore size also differs much from sizes given in the books, and the words warted and spinulose, as applied to spore sculpture, are often used synonymously. Such characters must be judged in relation to other characters that may be present, or in relation to those of the nearest related species.

The entire Long Island collections are considered a part of the Herbarium of The New York Botanical Garden, although remaining in my temporary custody for further study and comparisons. There is much duplicate material which is available to students in exchange for other specimens, properly matured, mounted,



and named. I shall be glad to extend aid and advice to others who may take up the study, and to determine forms that are sent to me properly mounted in the manner described. Each specimen should be glued into a separate, small, box, carrying the place and date of collection, and the habitat, if possible. There should also be a number, that corresponds to a similar number affixed to the part of the material retained by the correspondent, as the specimen will not be returned, and the determination will be made by number. The specimen sent should be of sufficient size, a square inch or so, to permit proper examination.

My thanks are due to Miss G. Lister and Dr. W. C. Sturgis, for the aid extended on many occasions in the determination of obscure specimens. The late Prof. T. H. Macbride, and the late Mr. Hugo Bilgram have also helped me greatly through correspondence. I recall with gratitude that the late Mr. Harold Wingate, many years ago, induced me to follow the study which has been a source of much pleasure during spare hours.

In the next few pages, I have arranged, alphabetically, all species found on Long Island, together with the principal stations where they have been collected. The list is of little interest to the distant reader. To the increasing number of students among the large population of New York City and its environs, it is of value as indicating definite localities where certain species may be found at appropriate times. A visit to the localities, more fully described in earlier pages, will do much to awaken an interest, which will become greater with observations under natural conditions, and the assurances that prolific developments will be found.

The species notes follow in alphabetical order, as there is no necessity for classifying them otherwise.

1. Albertson
2. Mill Neck
3. Mineola
4. Jones Beach

5. Meadow Brook
6. Great Neck
7. Deer Park
8. Various

	1	2	3	4	5	6	7	8
<i>Amaurochaete fuliginosa</i> (Sow.) Macbr. ....								*
<i>Arcyria carnea</i> G. Lister .....	*							
<i>cinerea</i> (Bull.) Pers. ....	*	*	*	*	*	*	*	*
<i>denudata</i> (L.) Wettst. ....	*	*	*	*	*	*	*	*
<i>ferruginea</i> Sauter .....	*							*
<i>incarnata</i> Pers. ....	*	*	*			*	*	*
<i>insignis</i> Kalch. & Cooke .....	*	*	*	*				*
<i>magna</i> Rex .....	*							*
<i>nulans</i> (Bull.) Grev. ....	*	*	*	*		*		*
<i>occidentalis</i> (Macbr.) Lister .....	*							
<i>Oerstedtii</i> Rost. ....	*					*		
<i>pomiformis</i> (Leers) Rost. ....	*	*	*	*		*	*	*
<i>stipula</i> (Schw.) Lister .....	*	*	*			*	*	*
<i>Budhamia affinis</i> Rost. ....			*					
<i>decipiens</i> (Curtis) Berk. ....					*			
<i>foliicola</i> Lister .....			*	*				*
<i>gracilis</i> Macbr. ....								*
<i>lilacina</i> (Fries) Rost. ....		*			*			
<i>magna</i> Peck .....			*					*
<i>orbiculata</i> Rex .....								*
<i>panicea</i> (Fries) Rost. ....	*	*						
<i>papaveracea</i> Berk. & Rav. ....			*					
<i>rubiginosa</i> (Chev.) Rost. ....		*					*	
<i>utricularis</i> (Bull.) Berk. ....			*					
<i>Brefeldia maxima</i> (Fries) Rost. ....						*		
<i>Ceratiomyxa fruticulosa</i> (Muell.) Macbr. ....	*	*	*	*	*	*	*	*
<i>Cienkowskia reticulata</i> (Alb. & Schw.) Rost. ....			*					
<i>Clastoderma Debaryanum</i> Blytt .....	*	*			*			*
<i>Comatricha elegans</i> (Racib.) Lister .....	*	*	*	*	*			*
<i>extendens</i> Hagelstein .....								*
<i>irregularis</i> Rex .....		*				*		
<i>laxa</i> Rost. ....	*	*		*				*
<i>longa</i> Peck .....	*				*			*
<i>lurida</i> Lister .....	*							
<i>nigra</i> (Pers.) Schröt. ....	*	*	*	*	*			*
<i>pulchella</i> (Bab.) Rost. ....	*			*		*		
<i>Rispaudii</i> Hagelstein .....	*							
<i>rubens</i> Lister .....	*					*		
<i>subcaespitosa</i> Peck .....	*	*			*	*		*
<i>typhoides</i> (Bull.) Rost. ....	*	*		*	*		*	*
<i>Craterium aureum</i> (Schum.) Rost. ....	*	*						
<i>concinnum</i> Rex .....	*							
<i>cylindricum</i> Massee .....		*	*			*		
<i>leucocephalum</i> (Pers.) Ditmar .....				*	*	*		*
<i>minutum</i> (Leers) Fries .....	*	*				*		*

	1	2	3	4	5	6	7	8
<i>Cribraria argillacea</i> Pers.....	*	*		*				*
<i>dictydoides</i> Cooke & Balf.....	*	*	*	*	*		*	*
<i>intricata</i> Schrad.....	*	*		*			*	*
<i>laxa</i> Hagelstein.....	*							
<i>macrocarpa</i> Schrad.....							*	
<i>microcarpa</i> (Schrad.) Pers.....	*	*	*	*	*			*
<i>minutissima</i> Schw.....				*				
<i>piriformis</i> Schrad.....								*
<i>tenella</i> Schrad.....	*	*		*				*
<i>vulgaris</i> Schrad.....	*	*		*	*		*	*
<i>Diachea leucopodia</i> (Bull.) Rost.....	*	*				*		*
<i>Dictydiaethalium plumbeum</i> (Schum.) Rost.....	*	*						*
<i>Dictydium cancellatum</i> (Batsch) Macbr.....	*	*	*	*	*		*	*
<i>Diderma effusum</i> (Schw.) Morgan.....	*	*	*	*	*	*		*
<i>floriforme</i> (Bull.) Pers.....	*	*	*	*	*	*	*	*
<i>hemisphaericum</i> (Bull.) Hornem.....	*	*	*		*	*		*
<i>montanum</i> Meylan.....	*	*		*	*			*
<i>radiatum</i> (L.) Morgan.....	*	*		*	*	*		*
<i>simplex</i> (Schröt.) Lister.....	*	*		*	*	*		*
<i>spumarioides</i> Fries.....	*	*			*			*
<i>testaceum</i> (Schrad.) Pers.....	*	*						*
<i>Didymium anellus</i> Morgan.....	*		*	*				*
<i>Clavus</i> (Alb. & Schw.) Rab.....	*		*	*				*
<i>difforme</i> (Pers.) Duby.....	*	*	*		*			*
<i>eximium</i> Peck.....	*	*						*
<i>minus</i> Morgan.....	*	*						*
<i>nigripes</i> (Link) Fries.....	*							*
<i>ochroideum</i> G. Lister.....	*	*	*	*	*	*		*
<i>squamulosum</i> (Alb. & Schw.) Fries.....	*	*	*	*	*	*		*
<i>xanthopus</i> (Ditmar) Fries.....	*	*	*		*	*		*
<i>Enerthenema Berkeleyanum</i> Rost.....			*					*
<i>papillatum</i> (Pers.) Rost.....	*	*	*	*		*		
<i>Enteridium olivaceum</i> Ehrenb.....	*	*	*					*
<i>Rozeanum</i> Wingate.....	*	*					*	*
<i>Fuligo cinerea</i> (Schw.) Morgan.....	*		*					*
<i>septica</i> (L.) Weber.....	*	*	*	*	*	*	*	*
<i>Hemitrichia clavata</i> (Pers.) Rost.....	*	*	*	*		*	*	*
<i>intorta</i> Lister.....							*	*
<i>Serpula</i> (Scop.) Rost.....	*	*	*	*	*		*	*
<i>stipitata</i> (Masse) Macbr.....	*	*					*	*
<i>vesparium</i> (Batsch) Macbr.....	*	*		*		*	*	*
<i>Lachnobolus congestus</i> (Somm.) Lister.....			*					*
<i>Lamproderma arcyronema</i> Rost.....	*				*			*
<i>columbinum</i> (Pers.) Rost.....	*	*			*			*
<i>scintillans</i> (Berk. & Br.) Morgan.....	*		*	*				*
<i>violaceum</i> (Fries) Rost.....		*						*

	1	2	3	4	5	6	7	8
<i>Leocarpus fragilis</i> (Dickson) Rost. ....	*	*				*		*
<i>Licea biforis</i> Morgan .....		*			*			*
<i>Lindbladia effusa</i> (Ehrenb.) Rost. ....	*			*				
<i>Lycogala epidendrum</i> (L.) Fries .....	*	*	*	*			*	*
<i>exiguum</i> Morgan .....		*					*	*
<i>flavofuscum</i> (Ehrenb.) Rost. ....	*				*	*		*
<i>Mucilago spongiosa</i> (Leyss.) Morgan .....	*							
<i>Oligonema flavidum</i> Peck .....	*	*				*		
<i>nilens</i> (Lib.) Rost. ....	*		*	*				*
<i>Perichaena chrysosperma</i> (Currey) Lister .....	*		*		*	*		*
<i>corticalis</i> (Batsch) Rost. ....	*	*	*		*			*
<i>depressa</i> Libert .....	*		*			*	*	*
<i>vermicularis</i> (Schw.) Rost. ....		*	*	*				*
<i>Physarella oblonga</i> (Berk. & Curt.) Morgan .....	*		*			*		*
<i>Physarum bogoriense</i> Racib. ....				*				
<i>cinereum</i> (Batsch) Pers. ....	*	*	*	*	*	*		*
<i>citrinum</i> Schum. ....	*					*		
<i>compressum</i> Alb. & Schw. ....	*			*				*
<i>confertum</i> Macbr. ....	*				*			*
<i>didermoides</i> (Ach.) Rost. ....	*		*					*
<i>flavicomum</i> Berk. ....	*			*				*
<i>galbeum</i> Wingate .....	*	*		*	*			*
<i>globuliferum</i> (Bull.) Pers. ....	*	*	*		*	*		*
<i>gyrosum</i> Rost. ....			*					*
<i>lateritium</i> (Berk. & Rav.) Morgan .....	*						*	*
<i>melleum</i> (Berk. & Br.) Massee .....	*		*	*		*		*
<i>murinum</i> Lister .....	*	*				*	*	*
<i>notabile</i> Macbr. ....		*					*	*
<i>nucleatum</i> Rex .....	*	*			*	*		*
<i>nulans</i> Pers. ....		*	*	*				*
<i>oblatum</i> Macbr. ....	*			*				
<i>penetrans</i> Rex .....		*						
<i>Physarum polycephalum</i> Schw. ....	*					*		
<i>pulcherrimum</i> Berk. & Rav. ....								*
<i>pusillum</i> (Berk. & Curt.) Lister .....	*	*	*	*				*
<i>rubiginosum</i> Fries .....								*
<i>sinuosum</i> (Bull.) Weinm. ....	*	*			*	*		*
<i>tenerum</i> Rex .....	*	*				*		*
<i>variabile</i> Rex .....	*							*
<i>virescens</i> Ditmar .....	*				*			*
<i>viride</i> (Bull.) Pers. ....	*	*	*	*	*	*	*	*
<i>Reticularia Lycoperdon</i> Bull. ....	*	*						*
<i>Stemonitis axifera</i> (Bull.) Macbr. ....	*	*					*	*
<i>carolinensis</i> Macbr. ....	*							
<i>confluens</i> Cooke & Ellis .....			*					*
<i>fenestrata</i> Macbr. ....	*							*

	1	2	3	4	5	6	7	8
<i>flavogenita</i> Jahn . . . . .	*							
<i>fusca</i> Roth . . . . .	*	*	*			*		*
<i>herbatica</i> Peck . . . . .	*			*	*			*
<i>hyperopta</i> Meylan . . . . .	*	*						*
<i>pallida</i> Wingate . . . . .	*	*						
<i>Smithii</i> Macbr. . . . .	*	*		*	*	*		*
<i>splendens</i> Rost. . . . .	*	*				*		*
<i>trechispora</i> Macbr. . . . .	*	*						*
<i>virginiensis</i> Rex . . . . .	*							
<i>Webberi</i> Rex . . . . .				*				
<i>Trichia affinis</i> de Bary . . . . .	*	*				*	*	*
<i>alpina</i> (R. E. Fries) Meylan . . . . .								*
<i>Botrytis</i> (Gmel.) Pers. . . . .	*				*		*	
<i>contorta</i> (Ditmar) Rost. . . . .	*							
<i>decepiens</i> (Pers.) Macbr. . . . .	*	*						*
<i>favoginea</i> (Batsch) Pers. . . . .	*						*	
<i>floriformis</i> (Schw.) G. Lister . . . . .	*	*						*
<i>inconspicua</i> Rost. . . . .	*	*				*		*
<i>persimilis</i> Karst. . . . .	*	*		*			*	*
<i>pulchella</i> Rex . . . . .	*	*				*	*	*
<i>scabra</i> Rost. . . . .	*	*				*	*	*
<i>varia</i> Pers. . . . .	*	*		*		*	*	
<i>Tubifera Casparyi</i> (Rost.) Macbr. . . . .							*	*
<i>ferruginosa</i> (Batsch) Gmelin . . . . .	*	*		*		*	*	*
<i>stipitata</i> (Berk. & Rav.) Macbr. . . . .	*	*						

## 1. AMAUROCHAETE Rost.

The genus is closely related to *Stemonitis* and *Comatricha* as the irregular columellae and capillitium bear a resemblance thereto. The fructification is in aethalia, not in sporangia; the capillitium more or less netted; and the spores in all but one species, are large and dark in color. In *Stemonitis trechispora* Macbr., there are irregular forms that approach *Amaurochaete*.

1. AMAUROCHAETE FULIGINOSA (Sow.) Macbr. A single collection of this slime mold was made at the estate of A. G. Hodenpyl, near Locust Valley, in September, on cut, piled, timber, and is quite typical. The aethalium is irregularly circular, about 2.5 cm. in diameter, and the spores, generally are 12  $\mu$ , but frequently larger.

## 2. ARCYRIA Wiggers

The sporangia are stalked, with a well developed cup, and a capillitium consisting of a more or less elastic network of threads, variously ornamented, but not with distinct spirals as in *Hemi-*

*trichia*. The colors of the species represented on Long Island are shades of red, yellow, white or gray. In the separation of species, the capillitial markings and spore size are of secondary importance to the characters of shape, color, stalk, cup, and manner of attachment of the capillitium to the cup, except in *A. ferruginea* where the spores are larger than in other species of the genus. In all species, including the white ones, there is a tendency to change to a yellow color on long exposure to daylight.

1. *ARCYRIA CARNEA* G. Lister. A study of the original description and figures of Miss Lister in the Journal of Botany will give a better idea of the characters and affinities of this species than the description in the Monograph.

The species has been found a number of times on Long Island, always on stumps or logs in July and August, and much earlier than the fruiting period here of *Arcyria insignis*. It has the color, cup, and short stalk of the latter species, but the sporangia are larger and the habit is different. The fruitings are small, consisting rarely of more than three or four closely compacted clusters of sporangia, and the clusters are much larger, usually from 10 to 20 mm. across. The sculpturing of the capillitium is more pronounced, appearing as stout protuberances with blunt or truncate ends. In typical examples, the capillitium is attached to the cup at many points, but there are other collections, otherwise similar, where it is lightly attached and these are close to *Arcyria incarnata*. The species appears to be intermediate between *A. insignis* and *A. incarnata*, but is undoubtedly near to pink or flesh colored forms of the last named, and may be an irregular phase thereof.

2. *ARCYRIA CINEREA* (Bull.) Pers. Abundant throughout the season from June to October. Distinctly yellow forms are common, but not significant, because of the tendency to change in color by exposure to daylight. Pink forms are also found occasionally. There is much variation in the shape of the sporangia, and collections on grasses at Jones Beach, with minute, globose or ovoid sporangia, may, with more reason, be placed with *Arcyria pomiformis*. The capillitiums, however, are close and dense as in *A. cinerea*.

Var. *DIGITATA* (Schw.) G. Lister is not so common but has been found in large and beautiful developments in the Albertson kettle

hole, and also at various other places. In all instances, the partly coalescent stipes retain their identity, and in many the separation at the base is widely divergent. In some clusters, the stipes bend closely together at the middle, without joining, and with intermediate stages of approach. I have a specimen from Trinidad, B. W. I., where the stipes are completely merged into a heavy stalk and another, imperfectly matured, from the Adirondacks, where typical *A. cinerea* and var. *digitata* are developing from the same plasmodium. All these phases, in my opinion, cannot be regarded as more than varietal, although a species may be in the making. They may be dependent upon conditions prevailing at the time of fructification.

3. *ARCYRIA DENUDATA* (L.) Wettst. Abundant here as it is almost everywhere. It is readily recognized by its red color, large size, long and dark stalk, and the firm attachment of the capillitium to the cup.

4. *ARCYRIA FERRUGINEA* Sauter. The species occurs on Long Island in two distinct phases. The first was collected in May and October of the same season, in the Albertson kettle hole, and agrees with English specimens that I have. The sporangia are large, 2–2.5 mm. in total height, with a very elastic, expanding capillitium, so that when fully expanded the height may reach 3 mm. The color is red with a tinge of brown. The threads of the capillitium are 5–6  $\mu$  in breadth, varying little from the basal threads which are not unusually long. The spores are 9.5–10  $\mu$  in diameter. It appears to be typical *A. ferruginea*.

The other phase is entirely different in appearance. The sporangia are small, 0.08–1.4 mm. in total height. The capillitium is compact, non-expanding, with closely spinulose, flattened, threads, 5–8  $\mu$  in breadth, and attached to the cup by one or two extremely long basal or connecting threads. These threads are frequently as long as 10 mm., but much narrower than the upper ones, 2.5–3.5  $\mu$ . The spores are larger than in the other phase, 10.5–11.5  $\mu$ . Otherwise, there are no important differences in the capillitium, spores, or cup. We have observed one fruiting of this phase, in the field, from the emergence of the pink colored plasmodium to complete maturity, which required six days. At first brownish-red, the color changes finally to yellow throughout the entire spo-

rangium, from stalk to spores. We were obliged to remove the fruiting, with impending rain, so that the process was not complete in all sporangia. The color of the remaining sporangia has not changed since removal, although exposed to direct sunlight for several days.

This form has now been found six times on Long Island, at widely separated places in different years; and we have also found it recently in the Adirondack Mountains. All of the collections are similar, varying insufficiently to differentiate between them. In some, the free ends of the capillitium are more numerous and in others, the reticulation of the capillitium is more pronounced. I regard all as *Heterotrichia Gabriellae* Masee, allowing for possible errors in description, or particular emphasis that Masee may have laid upon inconstant characters. The spore size as given by Masee is 7-8  $\mu$ . Miss Lister records it as 10-11  $\mu$  after examining the type specimen. Our forms from Long Island, perfectly mature and constant, are sharply different from typical *A. ferruginea*, but are unquestionably *Arcyria*. If time should reconcile them with the South Carolina form of Masee, all may well be regarded as examples of a distinct species, *Arcyria Gabriellae*, rather than a variety of *A. ferruginea*.

5. *ARCYRIA INCARNATA* Pers. Far more abundant than *A. ferruginea*, and found at every important station where we have collected. It is very variable in capillitium, cup, spores, stalk, and color; and there are many intermediate forms approaching *A. ferruginea* or *A. denudata*. Two collections from Mineola have spores 9-9.5  $\mu$  in diameter, others are 8-9  $\mu$ . In several collections the capillitium is more firmly attached, like in *A. denudata*, but the color and other characters are more like those of local *A. incarnata*. A peculiar specimen from the Deer Park forest has free elaters instead of the usual capillitial net. The elaters are long or short, frequently terminating at both ends with bulbous thickenings and blunt points, the latter occasionally bifurcate. It developed, probably, under adverse conditions.

Var. *FULGENS* Lister has been found three times. It has longer and firmer stalks, and the color is brownish-red like that of our local *A. ferruginea*. The spores are up to 8.5  $\mu$  diameter, and



except for the smaller spores, there is nothing to distinguish it from *A. ferruginea*.

6. *ARCYRIA INSIGNIS* Kalch. & Cooke. The species bears no resemblance to *A. denudata* in size, color, habit, or habitat. Typical fruitings occur as small sporangia, in numerous small clusters a few millimeters across, and of a salmon color. They are on ground debris of leaves, twigs, and grass, or the stems of living plants, indicating that the plasmodia thrive in the substratum. It has been found behind my home at Mineola on living lilac; on sedges, stems, and dried eel grass, at Jones Beach; and at other places throughout the area; so that it is not uncommon during the late summer. In *Mycologia* 21: 297-299, I proposed the var. *dispersa* for scattered and separated sporangia of this species that occur on dead grasses at Jones Beach. Numerous other minute, solitary sporangia are found there on the same grasses, and in color, shape and other characters are more like *A. pomiformis*, *A. cinerea*, or *A. denudata*, all of which develop normally at the same place. These should all be regarded as weak phases and not distinct variations, and as the var. *dispersa* is among them, I suggest its abandonment as needlessly encumbering the nomenclature.

We have often found small fruitings of an *Arcyria* colored like *A. insignis*, but larger in size, which in the past I have considered as var. *major* G. Lister. A further study of all of the material convinces me that it is not var. *major*. Those forms with long, dark red or brown stalks are *A. denudata*, and the majority, with short stalks and blunt prominences on the capillitium, are regarded as *A. carnea*.

7. *ARCYRIA MAGNA* Rex. A large and remarkable collection of this questionable species was made at Albertson, in September 1928. It appeared on an old log from which *Arcyria nutans* had been taken in a previous season, and *Arcyria cinerea* collected in close proximity. The fruiting was in a perfect state of maturity, and assumed to consist entirely of *A. magna*, but on closer examination it was observed that at one end it merged gradually into *A. cinerea*, including clusters with connected stipes, as in var. *digitata* of the latter species. This end had rather large, almost white sporangia, on long stalks, 6 mm. high in all, and a closely

meshed, non-expanding capillitium firmly attached to the cup. The size of the sporangia gradually decreased, meeting small forms of *A. magna*. About four-fifths of the development consisted of gray sporangia, with widely expanded, loosely meshed, drooping, capillitiums, 10–12 mm. in length, and very lightly attached to sessile or shortly stalked cups, when these were present. Frequently the capillitiums arise directly from the hypothallus by a few threads, without stalks or cups. The threads of the elastic network of the capillitium are pale yellow, about  $3\mu$  wide, and ornamented with spines, cogs, and half rings. The spores are  $7.5\text{--}8\mu$  diam., pale yellow, and faintly warted. The capillitium and spores are identical with those of *A. nutans* from the same locality, and the sporangia are practically the same otherwise, except in color. The threads of the inelastic capillitium of *A. cinerea* are pale yellow, somewhat thinner, and ornamented as in *A. magna*. The spores are pale yellow, faintly warted, about  $8\mu$  in diameter. A large part of the collection has been on exhibition, for a year or more, in the Museum of The New York Botanical Garden, and during that time, exposed to daylight, it has acquired a distinctly yellow hue.

Another small collection of *A. magna*, made at Albertson in July 1933, is the same as the earlier one, except that the sporangia have well developed cups and short stalks, and *A. cinerea* is not present. The capillitium of another specimen, collected by Mr. Charles W. Roessle, in Brooklyn in 1928, is the same as in the Albertson specimens.

Miss Lister regards *A. magna* as a phase of *Arcyria Oerstedtii*, basing the opinion upon the presence of peridial fragments attached to the capillitium in a roseate form that Rex considered a variety of *A. magna*. There are no indications of peridial attachments in the gray forms from Long Island, and the roseate form of Rex may have had a different life history.

*Arcyria magna* is one of those forms that are rarely reported. It is possible, in the early part of the life cycle of the Mycetozoa, that gametes of different species may fuse occasionally and form a plasmodium whose fructification will be a hybrid between the two parents. The field conditions and study of the gray forms here

reported indicate that they are hybrids between *A. nutans* and *A. cinerea*.

8. *ARCYRIA NUTANS* (Bull.) Grev. Easily recognized by the large, yellow sporangia, with expanding capillitium that is almost free from the cup. Common throughout the season, although the larger fruitings occur in June.

9. *ARCYRIA OCCIDENTALIS* (Macbr.) Lister. One collection from Albertson is typical but others from various stations show an approach to either *Arcyria ferruginea* or *Arcyria stipata*, by differences in the spore size or variations in the markings of the capillitium. All, more or less, show the color change from brown or red to drab yellow, which is also frequently observed in certain phases of *A. stipata*. My specimens have slightly elastic capillitia, so that I cannot agree with placing the species in the genus *Lachnobolus*, to which it is not related otherwise than by the flaccid character of the capillitium in specimens from other parts of North America. The species seems to be on the line of transition from *A. stipata* to *A. ferruginea*.

10. *ARCYRIA OERSTEDTII* Rost. Only one certain collection of this species has been made, at Albertson in June 1924. It is typical, with numerous plates from the peridium attached to the capillitium, but the spines on the latter are not as long as usual. A second collection, from Great Neck, is placed here doubtfully. The capillitium is densely spinose, with spines 2–2.5  $\mu$  in length; the spores are warted, 8–8.5  $\mu$  diam.; the cup papillose and strongly reticulate with raised ridges. Both fruitings are perfectly matured and the color is brownish-red.

11. *ARCYRIA POMIFORMIS* (Leers) Rost. When typical, the small, globose, buff colored sporangia with a more open capillitium, distinguish the species from *A. cinerea*. The habit is also more scattered with fewer sporangia to the fruiting. It is common, and found everywhere on Long Island, but not abundant. There are numerous intermediate forms that connect it with *A. cinerea*.

12. *ARCYRIA STIPATA* (Schw.) Lister. The sporangia have a long period of development, with the consequent hazards of interruption during the process, which accounts for the many imperfect and immature forms that are found. In perfect developments the sporangia are well separated, of a brown, copper color,

and have an elastic capillitium. Imperfectly matured forms run to duller red, with the sporangia superimposed and jumbled together. Some of our collections have pronounced spiral windings on parts of the capillitium, but never on the whole, nor as regular as in species of *Hemitrichia*. The numerous, wide-based protuberances, pointed or truncate, are like those in *Arcyria*, and, all in all, the form when properly matured, looks more like an *Arcyria* than a *Hemitrichia*. The species is on the border between the two genera, and will likely continue to be a bone of contention as to where it belongs. It merges gradually into *Arcyria occidentalis*, with a line of intermediate forms connecting the latter with *Arcyria ferruginea*. Abundant on Long Island in numerous phases, on wood throughout the season, but more often collected in the later months from September on.

### 3. BADHAMIA Berk.

The species of *Badhamia*, other than *B. foliicola*, have seldom been found in the area covered. The capillitium is calcareous throughout with only an occasional, short, hyaline connecting thread. Intermediate forms resembling species of *Badhamia* have longer threads between the calcareous nodes, and are difficult to determine, as they indicate a physaroid character. It is necessary to assign them to *Physarum connatum* (Peck) Lister, *Physarum leucophaeum* Fries, or *Physarum notabile* Macbr., but there is no unanimity of opinion as to the distinctions between the last three.

1. *BADHAMIA AFFINIS* Rost. In June 1928, Mr. Rispaud found a small fruiting of a *Badhamia* developing on his lawn from a white plasmodium. The sporangia are sessile, appearing otherwise like *Badhamia foliicola* which has been collected nearby on several occasions. *B. foliicola* develops from a yellow or orange plasmodium. The spores of the collection are free, spinulose, and 11–15  $\mu$  in diameter, the smaller spores predominating. The form is not typical, but the presence of the larger spores and the white plasmodium indicate a close approach to *B. affinis*.

2. *BADHAMIA DECIPIENS* (Curtis) Berk. The yellow sporangia with yellow line in the capillitium and free spores were found in the marshy land adjoining Meadow Brook, in what is now Meadow Brook State Park. One collection, in October.

3. *BADHAMIA FOLIICOLA* Lister. The species has been collected so often and at so many places from July to November in various years, that it may be regarded as one of our common forms. It seems to be almost unknown in this country, but has been found often, probably, and mistaken for some other *Badhamia* as it resembles a number of them in several of its phases. The sporangia develop in numerous, small patches on ground debris of sticks, twigs, grass, and leaves, and exhibit considerable variation. The color is a beautiful, iridescent, bluish-gray, with occasional patches having more lime in the peridium and showing white. Some patches consist entirely of sessile sporangia; in others, they are shortly stalked, the stalks, in length, less than the diameter of the sporangia. The stalks may be yellow and weak, or streaked with gray to almost black, or may be firmer. The spores range widely in their size, color, and markings, and are usually free, although sometimes in loose clusters, and, occasionally in fresh material, are firmly adherent, but separating later. An entire collection must be studied in its various phases in order to make a proper determination when the student is not familiar with the species. The form differs from all others with which it may be associated, by the habitat when clearly known; from *B. utricularis* by the shorter stalks; from *B. papaveracea* and *B. affinis* by the spore characters; and from *B. panicca* by the absence of the red hypothallus and the much more delicate capillitium.

4. *BADHAMIA GRACILIS* Macbr. A collection of this graceful species was made on bark in October, and compared with authentic specimens sent to me by Dr. G. W. Martin. In our material the spores are about 12  $\mu$ , closely warted, and some of the spores have a few small clusters of warts, or a line of warts across the hemisphere. The species was formerly regarded as a variety of *Badhamia macrocarpa* (Ces.) Rost., but the latter has not been seen on Long Island.

5. *BADHAMIA LILACINA* (Fries) Rost. The sporangia are pinkish or flesh colored when fresh, fading later to white. The peridial wall is opaque with lime and looks like a Diderma, but the capillitium is diagnostic. Our two collections were made at Mill Neck and Meadow Brook Park during the late summer and early fall, on stalks of living ferns and dead leaves.

6. *BADHAMIA MAGNA* Peck. The species was found in an advanced state of maturity, on a pile of stacked fire wood, when we visited the estate of William Willock, at East Norwich, during October. The following October, perfect collections were made a week earlier. Apparently it fruits but once a year, in this instance practically to a day, and we have noted this, occasionally, in other species. The golden yellow stalks are in many instances more than 5 mm. in length with large clusters of sporangia at the tops. There is much branching and joining of the stalks and frequently a number will coalesce from the base up—as in *Arcyria cinerea* var. *digitata*—to form a single, erect column supporting from forty to fifty sporangia. The latter phase presents one of the most handsome slime molds that I have seen. The spores are free, spherical, faintly spinulose, 10–11  $\mu$  diam.; the color is violet-brown, but not very dark.

7. *BADHAMIA ORBICULATA* Rex. Appeared in abundance on a locust arbor in the gardens of Doubleday, Doran & Co. at Garden City, and a year later on locust wood in Mineola, both appearances in July. Typical sporangia are sessile or shortly stalked, flattened and circular with a small depression in the center. The shape is formed by the plasmodium spreading horizontally as an open ring, the two ends of which finally join and close the middle, but leave the small circular or linear depression. There are numerous examples showing the junction lines of the fusion, and others where two or more sporangia have fused together. The capillitiums show by plates or thickenings along the lines of junction that they have followed the sporangial formation. Ring shaped plasmodiocarps are not unusual among the Mycetozoa, but here we see the process in its highest development with the ultimate formation of circular sporangia and the disappearance of all vestiges of the merging.

The method of sporangial formation is sufficient, in my opinion, to regard *B. orbiculata* as a distinct species, rather than to consider it as a variety of another where the process is outward in all directions possible, and not as a horizontal ring. The species, so far as reported, occurs only in North America and Asia.

8. *BADHAMIA PANICEA* (Fries) Rost. Occurs on dead wood in

the early part of the season to July inclusive. It has been collected in two successive years from the same log in the Albertson kettle hole, and also at Mill Neck. Externally, the sporangia resemble certain phases of *B. foliicola*, but the species is readily recognized by the reddish hypothallus which is present in all our specimens; the densely calcareous capillitium with a tendency to form a pseudo-columella; and the habitat.

9. *BADHAMIA PAPAVERACEA* Berk. & Rav. Represented by a single, small collection from a stack of fire wood in Mineola. The sporangia are typical with short, thick, black stalks, and spores firmly adherent in clusters.

10. *BADHAMIA RUBIGINOSA* (Chev.) Rost. While not common, the fructifications are frequently of great size. On two occasions in the Mill Neck swamp, the sporangia covered the stalks of living ferns for many yards around. Another collection on wood made in early February during an open winter has many sporangia with the tops breaking away as distinct lids. This feature caused earlier authors to place the species in *Craterium*.

11. *BADHAMIA UTRICULARIS* (Bull.) Berk. The species is related on one side to *B. foliicola* and on the other to *B. magna*, the principal distinction being in the length of the stalk, although in doubtful specimens the spore characters must be taken into consideration. In our single collection, on dead wood from Mineola, the thin stalks are, in length, two or three times the size of the sporangia, and the spores are free, lighter in color than those of our *B. magna*, but more strongly spinulose. September.

#### 4. *BREFELDIA* Rost.

A monotypic genus with a well marked species.

1. *BREFELDIA MAXIMA* (Fries) Rost. May be recognized in the field by the dark, purplish-brown aethalia which are seated on a wide-spreading hypothallus, and are as much as 30 cm. across. The peridium is weak, the mass of spores breaking away freely after drying. It occurs in the Great Neck kettle hole, where it has been found in October of several years on stumps or living trees, a few feet above the ground. The plasmodium is white.

## 5. CERATIOMYXA Schröter

The genus has but a single species, *C. fruticulosa* (Müll.) Macbr., which is different from all other Mycetozoa in that the spores are on the outside of sporophores instead of within sporangia or aethalia. Another form, *Ceratiomyxa porioides* (Alb. & Schw.) Schröt., has been often regarded as a distinct species, but the tendency now is to accept it as a variety or phase of the former. Some years ago, I found the two developing from the same plasmodium, and I have been informed by other students that the phenomenon is occasionally observed. The species is sensitive to atmospheric conditions prevailing at the time of fructification, and as these change or the habitat is different, various phases are produced. These are not varieties, although they may be conveniently regarded as such. They are not geographically restricted, forming wherever the species is abundant and the conditions suitable. Extremely moist conditions will produce the typical form and var. *porioides*, the latter, probably with lower temperatures as we have observed it only after cooler periods. On dry wood, or elevated from the ground and exposed to gentle air currents, the fructification will be as var. *arbuscula* Berk. & Br. or var. *filiformis* Berk. & Br., which two Lister combines as var. *flexuosa*, as there is little difference between them. In var. *arbuscula*, the sporophores are stouter and the branches flattened because of their greater breadth, while in var. *filiformis*, the branches are more slender and rounded. In both varieties, the upper branches of adjoining sporophores often intertwine to form a dense, matted, surface. These last phases represent the highest development of the species, and it is unfortunate that a phase developed under adverse conditions should be regarded as the typical form.

1. CERATIOMYXA FRUTICULOSA (Müll.) Macbr. Abundant everywhere on Long Island, from June to October, in all the varieties or phases mentioned. Cream colored, yellowish, or pinkish forms also occur, but have no particular significance as the color depends, probably, upon the nature of the food supply of the plasmodium. Var. *descendens* Emoto has also been observed and is here regarded as a phase. It is perhaps the same as var. *dentata* Minakata.



## 6. CIENKOWSKIA Rost.

The genus is monotypic, and the single species may be recognized with a hand lens after a study of its characters and relations as given in either the Lister or Macbride & Martin monographs.

1. CIENKOWSKIA RETICULATA (Alb. & Schw.) Rost. A collection on small sticks and twigs from Mineola, in July 1928, shows a tendency to flat, effused plasmodiocarps, although sufficient openings indicate the netted character. A second and larger collection, on the same habitat from another place in Mineola, and found in September 1933, consists of numerous, flattened, thinly effused plasmodiocarps up to 20 mm. long and 6 mm. wide, with only a few openings in one plasmodiocarp. The last collection has a rather scant capillitium.

## 7. CLASTODERMA Blytt

Like *Comatricha* or *Lamproderma* in outward appearance, but the threads of the capillitium are forked, with persistent plates from the peridium at the outer ends. A single species is known.

1. CLASTODERMA DEBARYANUM Blytt. The sporangia are very small, 0.1–0.2 mm. diameter, on long stalks which are almost black for the greater part of their length and brown above. Our Long Island material usually shows the reddish, swollen portion about two-thirds of the way up from the base, beyond which the stalk becomes abruptly thinner. It requires good eyes to see the form on wet wood, but it is no doubt abundant as Mr. Rispaud has found it often, at various places, from June to September.

## 8. COMATRICA Preuss

The genus, like *Stemonitis*, is a difficult one because of the many intermediate forms, and the absence of sharp distinctions between many of the species. It is separated from *Stemonitis* by the absence of the surface net to the capillitium, but in some species the net is more or less evident, although not so regular and well defined throughout as in *Stemonitis*. In studying the species of the genus, the characters of columella and capillitium are of primary importance.

1. *COMATRICHA ELEGANS* (Racib.) Lister. Mitchell Field is the permanent aviation post of the U. S. Army located near Mineola since the late war. During that period, lumber from all parts of the world has been brought there for various purposes of building construction, aeroplane work, etc., the poorer or decayed material eventually finding its way to the junk piles where we have made good collections. Our most interesting developments of *Comatricha elegans* came from there, and, show in an almost unbroken line of evolution the disappearance of the columella in the transition from *Comatricha nigra*. One fruiting has the stalks branching into two or three parts below and outside of the sporangia, each branch then forking within, the combined branches retaining the globose shape of the sporangia. The widest departure, where the columella is entirely absent and the capillitium expands and extends as a long cylindrical net, I have proposed as *Comatricha extendens*.

The Mitchell Field forms of *C. elegans* are shortly stalked, the stalks two or three times the size of the sporangia. It seems that variation is more evident in the shorter stalked forms, in some instances, developments from one plasmodium showing sporangia of both *C. nigra* and *C. elegans*. Often the capillitium is more lax, as in *C. lava*, and again, lighter colored spores, distinctly warted, show a tendency towards *C. pulchella*. Long stalked forms of *C. nigra* and *C. elegans* are usually constant in the characters of columella and capillitium throughout the fructification.

The species is fairly abundant on Long Island, and has been found at many places on wood, throughout the season.

2. *COMATRICHA EXTENDENS* Hagelstein. Found fruiting indoors on the under side of flooring among steam pipes, in a hot, moist, environment. The form lacks a columella and suggests a separate genus, but I am convinced that it is allied to *C. elegans* and should be regarded as a *Comatricha*. Externally, it looks like a long stalked phase of *C. nigra*, but the capillitium rises directly from the stalk, and finally expands into a narrow plume, two or three times the size of the sporangial body. Proposed, described, and figured in *Mycologia* 27: 374-375, 1935.

3. *COMATRICHA IRREGULARIS* Rex. Sometimes difficult to separate from *Comatricha longa* as intermediate forms occur and the

spores are often similar in both species. The smaller size, different habit, and capillitium distinguish *C. irregularis*. We have three collections, on wood during the autumn months.

4. *COMATRICHIA LAXA* Rost. The important difference from *C. nigra* is in the open character of the capillitium as mentioned under the latter species, and it is subject to similar variation. All of our material has short stalks, and it may be said, generally, that all shortly stalked forms of *C. nigra* show a tendency to a more open capillitium. *Comatricha Ellisii* Morgan, a form intermediate between *C. nigra* and *C. laxa*, and among our material, has a capillitium somewhat closer than typical *C. laxa* but comes within the range of variation common to many of the Mycetozoa. It is regarded here as a phase of *C. laxa* as, in my opinion, there is little to justify specific rank. *C. laxa* is well distributed on Long Island, on wood throughout the season.

5. *COMATRICHIA LONGA* Peck. The long, drooping, sporangia in clusters have been found frequently on wood from July to October.

6. *COMATRICHIA LURIDA* Lister. Collected twice on leaves in July 1927, at Albertson, and so far as I know these are the first recorded collections from North America. It is closely related to *Comatricha rubens*. The Long Island specimens have globose, light brown sporangia on short, slender stalks. The columella divides at the top into the primary branches of the capillitium, and, while some of the threads are bent downwards, there are no attachments to the lower part of the columella, nor is there any firm, peridial base, with attached threads, as in *C. rubens*. After spore dispersal, which commences at the bottom, the capillitiums appear somewhat scanty and assume a hemispherical shape on top of the bare columellae. This permits a rough method of field analysis in differentiating between the two species. If the tops are ragged, it is probably *C. rubens*. If after the spores have commenced to fall away the sporangia appear ragged at the bottom, it is probably *C. lurida*. The spores of *C. lurida*, in our specimens, are of a light, violet-gray color, irregularly globose, distinctly warted, and measure about 7  $\mu$ .

7. *COMATRICHIA NIGRA* (Pers.) Schröt. With *C. nigra* as a center, there are grouped a number of forms, closely affiliated, but which in their highest developments show such wide divergence in

the capillitium and columella, that they are regarded as distinct species. In typical *C. nigra*, the columella or continuation of the stalk passes through the sporangium to the top, or almost so, with the capillitium dense and attached by threads to all parts of the columella. When the capillitium becomes more open, the tendency is towards *C. laxa*, and in higher developments of the latter it consists of a widely meshed, loose net, not to be confused with the capillitium of any other *Comatricha*. In *C. elegans*, the columella divides into several branches forming the primary branches of the capillitium. In *C. extendens* there is a still further departure with the entire disappearance of the columella, and the netted capillitium springs directly from the top of the stalk.

*Comatricha nigra* is an abundant species on Long Island. It is subject to considerable variation in size and shape, often within the same fructification. The stalk varies in length, also the color and spore size. The majority of our specimens are globose, or nearly so; on long stalks; and of a dark, violet-brown color. Intermediate forms connecting it with *C. laxa* and *C. elegans* are not rare.

Var. *alta* (Preuss) Lister was collected once on dead, herbaceous stalks, at Albertson in June. The sporangia are shortly cylindrical, on long stalks with a weak upper capillitium.

8. *COMATRICHIA PULCHELLA* (Bab.) Rost. The sporangia, under a hand lens, appear somewhat like forms of *C. nigra* or *C. laxa*, but the color of the capillitium and spores is paler, and the latter are distinctly warted. Var. *fusca* Lister has a darker and more robust capillitium. Var. *gracilis* (Wingate) Lister has slender, cylindrical sporangia that must not be confused with *Comatricha subcaespitosa* which they resemble superficially. The typical form and varieties are fairly abundant on Long Island, throughout the season, on leaves, ground debris, or living plants, but not on wood.

9. *COMATRICHIA RISPAUDII* Hagelstein. Described in *Mycologia* 21: 297, 1929. It appeared on leaves at Albertson in July 1927, in various fruitings, and again in September 1931, the last agreeing in every respect with the earlier ones. A typical collection was also made by Mr. Rispaud at Enfield Gorge, near Ithaca, New York, in August 1935.

10. *COMATRICHA RUBENS* Lister. Found several times at Albertson and Great Neck, on leaves, and may occur annually, but has not been searched for in recent years. The sporangia are obovoid, light brown with a touch of pink, and quite typical with the persistent, membranous base of the sporangial wall attached by threads to the lower part of the columella. The spores are  $6.5\ \mu$  in diameter, faintly spinulose.

11. *COMATRICHA SUBCAESPITOSA* Peck. From correspondence with other students I find that this species is apparently not clearly understood, and is probably often confused with *C. typhoides* or var. *gracilis* of *C. pulchella*, both of which it resembles superficially. The Listers have regarded it as a variety of *C. nigra*, to which in my opinion it bears no relation, but Miss Lister in correspondence has indicated a change of opinion. The surface net to the capillitium is more striking and pronounced than in *C. typhoides*, and brings the species near to *Stemonitis*, but it is no doubt better to regard it as a *Comatricha* where its greater affinities lie.

The form is abundant on Long Island, throughout the season on wood, in large fruitings of closely aggregated sporangia, the fruitings sometimes a foot or more across. The sporangia are cylindrical, usually curved with few erect, of a dark brown color, and on short stalks one-quarter or less of the total height. The peridium is concolorous, not silvery and persistent as in *C. typhoides*, and vanishes rapidly. The stalk is bare and not sheathed with a thin membrane. The spores in considerable material examined range from  $6-8\ \mu$  and have a light violent-brown color by transmitted light. They are distinctly and uniformly warted, but never with the large, prominent, solitary warts observed on the spores of *C. typhoides*. It will be noted that the spore description does not agree with that given by Machride and Martin. The only outside specimen of *C. subcaespitosa* that I have is from Maryland, and the spores there are identical with the Long Island spores.

The form is remarkably constant so that tentative determinations may be made in the field with a hand lens on habit, shape, color, stalk, and absence of the silvery peridium. There is no question in my mind about its position as a distinct species.

12. *COMATRICHA TYPHOIDES* (Bull.) Rost. We have two phases of this species on Long Island, one developing on wood, and

the other with plasmodia vegetating in the moist sub-stratum, and fruiting on leaves and other ground material.

The wood form is fairly abundant throughout the season, in small fruitings rarely more than three inches across. The sporangia have the usual scattered habit; are lilac-brown in color; and have long stalks equal to or longer than the sporangial body. The persistent, silvery peridium is present, and the stalks generally show the thin, membranous sheaths. The spores are smaller and paler than those of *C. subcaespitosa*, and invariably have the few, large, scattered warts that are seen to best advantage in the field of the microscope when on the edge of the spore.

For ten years past, annually in June and July, we have noticed in the Albertson kettle hole, numerous large fruitings of *C. typhoides* on leaves. On one occasion, almost every dead leaf in an area of two hundred square feet or more bore its part of the many thousands of sporangia. There is nothing to distinguish these from typical *C. typhoides* on nearby wood, except that the stalks are slightly shorter, about one-third the total height. It is interesting, nevertheless, to note that in the ground of this morainal depression, the plasmodium has adapted itself from the wood in which heretofore it has always been found.

## 9. CRATERIUM Trentepohl

The genus is related to *Physarum* and *Badhamia*, but set off by the shape of the sporangia and the lids thereon. Both features are well represented in most of the species.

1. *CRATERIUM AUREUM* (Schum.) Rost. Collected repeatedly on leaves in the Mill Neck and Albertson swamps, during June and July. The sporangia, when fresh, are usually golden yellow, but one gathering is gray with a reddish tinge. The lime in the capillitium is yellow, but fades to white along with the sporangial color.

2. *CRATERIUM CONCINNUM* Rex. Found several times on leaves, twigs, and ground wood, prior to 1927 but not since, and only at Albertson. The habitat is not as usually reported, the chestnut being extinct in the neighborhood for many years back. It is smaller than *C. minutum*, the lid is not depressed, and the lime-knots are brownish-yellow, fading to impure white.

3. *CRATERIUM CYLINDRICUM* Massee. The form is well differentiated in its shape, and easily distinguished from *C. leucocephalum*. While related to the latter variable species, it is the most constant and abundant—at least in North America—of the various forms connected therewith. Following other American students, I believe that it should be regarded as a distinct species. It is common on Long Island, throughout the season from July, on leaves, twigs, and similar material. We have handsome developments with sporangia formed like inverted, elongated bells.

4. *CRATERIUM LEUCOCEPHALUM* (Pers.) Ditmar. Of our two collections on ground debris, each apparently of several fruitings, the one from Great Neck shows considerable variation and a tendency towards *C. minutum*, but the crystalline discs in the sporangial wall are prominent. The other, from Meadow Brook, is divided into numerous phases, some close to *C. minutum* in the smooth character of the wall. In the Meadow Brook specimens, the lids in all phases are convex, white or concolorous with the wall, smooth or wrinkled. There are no discs in the wall or capillitium, but the majority of the fruitings are undoubtedly *C. leucocephalum*, and in the uniform absence of the thickened wall below the lid, I regard them all as phases of the variable *C. leucocephalum*, rather than mixed fruitings of the two species.

Var. *scyphoides* (Cooke & Balf.) Lister has been found twice on ground debris. The turbinate sporangia with brilliant red bases, stalks, and hypothallus, are characteristic. The base, in instances, approaches a distinct calyculus or cup.

5. *CRATERIUM MINUTUM* (Leers) Fries. Not uncommon and well distributed. All our collections, but one, have the lids depressed below the margins. The other has convex lids with most of the sporangia long cylindric in shape.

## 10. *CRIBRARIA* Persoon

Taxonomically, *Cribraria* is a difficult genus for the most advanced student, and an unsolvable puzzle for the beginner. Many of the species have no definite boundaries; they overlap and merge into each other; and there is added confusion in the varying interpretations placed upon the same form by different students. I

confess that I do not understand the genus thoroughly, and other students may disagree with my opinions and conclusions, but in going over specimens in my herbarium that were determined by others, I do not agree with them in many instances. In the main I have followed Lister as offering a better conception of the species of the genus and their relations to each other, and have then adapted my impressions to our local variations. These variations range through all our forms except *C. argillacea*, *C. laxa*, and *C. minutissima*. The size, number, and color of the plasmodic granules as emphasized by Lister, I have found of great value in diagnosis, at times, but not always.

The Long Island species of *Cribraria* are found throughout the season, usually more abundant in July and August. Ten species, as here recognized, have been collected, most of them frequently, and all on wood except *C. laxa*.

1. *CRIBRARIA ARGILLACEA* Pers. Collected repeatedly at Jones Beach from July to October, also at Glen Cove. All collections are typical.

2. *CRIBRARIA DICTYDIOIDES* Cooke & Balf. Several species of *Cribraria* are so close to each other that they appear to be no more than varieties. Aside from minor, unimportant differences, *C. tenella* differs from *C. intricata* only in the shape or form of the nodes of the net, and *C. dictydioides* from *C. intricata* by the absence of a cup. In perfect developments, these distinctions are well marked, but there are all sorts of intermediates between the three as well as between them and other related species. *C. dictydioides* is abundant on Long Island as it is elsewhere in North America. It is so striking in appearance, that it can be identified often with a hand lens or with the unaided eye, which cannot be said about *C. tenella*. I believe, particularly in *Cribraria*, that when a form is well marked at the extreme end of the range, also abundant and cosmopolitan, that it should be regarded as a species, at least until it is proven that the differential character depends upon varying conditions at the time of fructification. The form so far has not been observed in the field here after August.

3. *CRIBRARIA INTRICATA* Schrad. Macbride and Martin say in the description that the calyculus is lacking. All of our material has distinct cups, usually about one-third the height of the sporan-



gial body, and I interpret this as the important distinction from *C. dictydioides*. The parallel connecting threads between the prominent, irregular shaped nodes of the net, as mentioned by some authors, I have never seen emphasized, and doubt their value as a diagnostic character. The form is abundant and well distributed here.

4. *CRIBRARIA LANA* Hagelstein. Described in *Mycologia* 21: 298, 1929. A further collection was made at the type locality in September 1931. It was small and injured by water, but otherwise typical. So far, five collections have been made, all alike and always on leaves.

5. *CRIBRARIA MACROCARPA* Schrad. Typical material has not been found. We have one collection from the forest near Deer Park that has many large sporangia showing the dark, ribbed formation of the cup, but otherwise intermediate with *C. intricata*.

6. *CRIBRARIA MICROCARPA* (Schrad.) Pers. Miss Lister, in the Monograph, records the color as purplish-red with the spores pale red in mass. Our forms are not so. The color is yellow or ochraceous before spore dispersal, and the spores are yellow in mass. After the spores are gone, the net appears brown from the color of the enclosed granules in the nodes. In all other respects they agree with the Lister description and figures.

*C. microcarpa* is a small form on long stalks without a cup, and with prominent, dark, rounded nodes to the net. It is close to *C. tenella*, and in fruitings with very small sporangia there are others that approach in size the cup-less form of the latter species. Abundant and well distributed on Long Island.

7. *CRIBRARIA MINUTISSIMA* Schw. A typical and well matured development was obtained at Jones Beach in July on a fallen telephone pole.

8. *CRIBRARIA PIRIFORMIS* Schrad. Two collections from Belmont State Park have pyriform sporangia with deeply dentate cups, the nodes and cups densely studded with large, dark granules up to  $2.5\ \mu$  in size. The spores measure  $6-7\ \mu$  diameter and are distinctly warted. The forms are not typical, but are close to *C. piriformis*. Other collections from Jones Beach are similar in sporangial shape and cups, but the granules are smaller and not so crowded. They are nearer *C. vulgaris* var. *aurantiaca*.

9. *CRIBRARIA TENELLA* Schrad. Differs from *C. intricata* in the shape of the nodes of the net which are small and rounded. Most of our material has typically sized cups, but in some where they are obsolete the approach is towards *C. microcarpa*. Var. *concinna* G. Lister has been kindly determined for me by Miss Lister from material sent to her. The specimen examined and similar ones from here do not differ in color from our local *C. microcarpa* nor are there any differences worth noting. I regard the two as synonymous. *C. tenella* is not as abundant as *C. intricata* or *C. dictydioides*, but often collected and well distributed.

10. *CRIBRARIA VULGARIS* Schrad. Easily recognized under the lens by the usually broad, flattened nodes of the net. Our material, when fresh, has orange colored spores in mass giving a reddish appearance to the fruiting, and permitting a tentative determination in the field.

The student who will carefully study the descriptions and notes about this species in the Lister Monograph, and about *Cribraria aurantiaca* in the Martin and Macbride book, will note a difference of opinion as to the distinctions between them. Those forms where the nodes are flattened, branching, and lighter in color because of the absence of granules, I regard as *C. vulgaris*. When the nodes are more convex, or darker and crowded with granules, I regard the form as *C. vulgaris* var. *aurantiaca* (Schrad.) Pers. There are all stages of variation between them, and usually the spores of both have the orange color. Var. *aurantiaca* gradually merges into forms with slightly pyriform sporangia that have deeply dentate cups, and nodes and cups densely studded with granules, approaching *C. piriformis*. Both the typical form and variety are abundant.

## 11. DIACHEA Fries

The genus connects the calcareous Mycetozoa with the Stemonitaceae. All but one of the species are rarely reported or only from certain localities.

1. *DIACHEA LEUCOPODIA* (Bull.) Rost. A handsome form easily recognized by the stout, white stalks and cylindrical sporangia, which are iridescent before the peridium vanishes. It is often found in large colonies on twigs and leaves, or spreading

over dead and living bushes. It is fairly abundant on Long Island, and may be expected anywhere on a suitable habitat after June.

## 12. DICTYDIAETHALIUM Rost.

There is only a single species which is well marked by capillitial characters so that it cannot be confused with anything else.

1. *DICTYDIAETHALIUM PLUMBEUM* (Schum.) Rost. Found frequently on wood, after August, and usually in single aethalia. We have ochraceous, gray, and olive colored forms. A collection of five aethalia on charred wood, from Lakeville, is red in color, but not properly matured. It is probably var. *cinnabarinum* (Berk. & Br.) Hiranuma, and the color appears to be due to imperfect maturity.

## 13. DICTYDIUM Schrader

The genus differs from *Cribraria* in the sporangial wall, which here has ribs connected by slender threads, instead of the more or less perfect net with expansions or thickenings at the nodes. There is but one species, which is abundantly distributed throughout the world.

1. *DICTYDIUM CANCELLATUM* (Batsch) Macbr. Var. *purpureum* Macbr. and var. *fuscum* Lister are well represented in the numerous collections of *D. cancellatum* that we have made. The first, based on color, shades into the brown, typical form, if any of the many phases may be called typical. Var. *fuscum*, as found here and elsewhere in North America, is the highest development of the species. It is well figured by Macbride, in the 2nd. edition of the North American Slime-moulds on plate 19, fig. 1. The color is dark brown, with the ribs and stalks almost black at times. The sporangia are bell-shaped, with a prominent calyculus, in all a shapely, beautiful form. All phases of the species are common throughout the area.

## 14. DIDERMA Persoon

The small, spherical, granules of lime in the sporangial wall are sometimes so small, that, when separated in water, they display

the phenomenon of the so-called Brownian movement. This is caused by the constant motion of the molecules of water, and the resultant variations in pressure upon the particles of lime.

Four of the species here reported are abundant and well distributed in the area, but the other four have been rarely observed.

1. *DIDERMA EFFUSUM* (Schw.) Morgan. Among the many collections that we have made, and it is one of our most abundant species, we can recognize four distinct phases or varieties into which all the material can be divided. All the phases are common throughout the season.

The first, which is always on leaves in dry places, is an extremely thin, effused, patch, rarely more than 3 or 4 cm. across, and about 0.1 mm. thick. The fructification is continuous, in an even thin mass, not broken into separate sporangia or plasmodiocarps, although sometimes reticulate or showing lines of entirely confluent plasmodiocarps. There is little capillitium as there is no room for it.

The second phase consists of individual plasmodiocarps and sporangia, usually separated, but sometimes partly confluent. Here the fructification is always more or less flattened, but much thicker than in the first mentioned phase, and consequently, with a better developed capillitium. This is regarded as the typical form.

The next is like the preceding, but here the wall is beset with many crystalline discs or scales, often as large as 0.2 mm. across. At times the discs are so numerous that the entire wall appears hyaline, with a yellowish tinge. The discs are set in the calcareous wall but may be easily removed, and are similar to those in the genus *Lepidoderma*, showing an approach to that genus. Otherwise it is normal *D. effusum* with a columella represented by the slightly thickened, yellow or brownish base, and pale, almost smooth spores, 6–7.5  $\mu$  diam.

This variety has been found at Mill Neck and other places on many occasions. I have seen no prior record of it and propose the name *hyalinum* as it is distinct and constant.

The last phase is var. *reticulatum* (Rost.) Macbr., with well rounded, separate sporangia and plasmodiocarps, and an abundant capillitium. It is the highest development of the species.

*D. effusum* is very variable, and by intermediate stages approaches *D. testaceum*, *D. spumarioides*, and *D. hemisphaericum*, all of which occur on Long Island. Bleached forms of *D. testaceum* may be distinguished by the large, dark, hemispherical columellae. *D. spumarioides* is recognized by the different habit, the larger and darker spores, the small, pale, columella, and the more or less adherence of the two layers of the sporangial wall. *D. hemisphaericum* resembles *D. effusum* when the stalks are absent, but the sporangia are discoid and larger.

2. *DIDERMA FLORIFORME* (Bull.) Pers. We have collected this species annually for a number of years, on and around a shaded stump at Albertson. Always in the period from early September until early November, and with but a single appearance, we conclude that here it is an autumn species, with but one annual fructification. We have it also from the Deer Park forest, on wood in October.

3. *DIDERMA HEMISPHAERICUM* (Bull.) Hornem. Frequent on leaves and other ground debris during July and August. A large gathering from Mineola has many sessile sporangia and plasmodiocarps, and approaches *D. effusum*.

4. *DIDERMA MONTANUM* Meylan. The species is so close to *Diderma radiatum* var. *umbilicatum*, that it is questionable if there are sufficient grounds for its separation. An authentic specimen kindly sent to me by Prof. Meylan is the same as our var. *umbilicatum*, except in the separable character of the inner sporangial wall. In the marsh at Meadow Brook, in late autumn, we find numerous small fruitings on mossy stumps that are close to the water's edge, many of which are poorly matured and others stained or bleached white. In fresh, perfectly matured specimens, the color is pinkish, with a dark red inner base, a red stalk, and the sporangia arise from a reddish hypothallus. The columella is small, very dark brown; the capillitium pale, hyaline; and the spores like those of *D. radiatum* or Prof. Meylan's specimen of *D. montanum*. The sporangial wall is clearly double, the inner membranous layer frequently separating from the outer one. The forms as described, I regard as *D. montanum*, but there are other fruitings from the same locality, where the double wall is not evident except in the dark coloring of the inner base, and these are

the same as forms from other marshy places in the area, and are *D. radiatum* var. *umbilicatum*.

I am of the opinion that *D. montanum* is the highest developed phase of *Diderma umbilicatum* Pers., and that the two are far more closely related than the latter is to *D. radiatum* of which it is considered a variety. A further and more exhaustive study of the North American material of *D. umbilicatum* may indicate that the presence of the double wall is more general than has heretofore been noticed, and that the wall structure is more like that of species in the subgenus *Eudiderma*. Most of our Long Island material follows that tendency.

5. *DIDERMA RADIATUM* (L.) Morgan. A small gathering of typical, brown sporangia, with stellately dehiscing walls, was made at Mill Neck, on wood. It seems to be rare, and local students are cautioned not to confuse it with *D. floriforme*, which it resembles in the field. The habit is separated, not crowded like in the latter species, and the spores, of course, entirely different. Var. *umbilicatum* (Pers.) Meylan has been found occasionally at several places, on mosses in the swamps, and also on wood at Jones Beach. Both are autumn forms, appearing after the middle of September. For further notes see *D. montanum*.

6. *DIDERMA SIMPLEX* (Schröt.) Lister. The belief that this species is rare in North America is apparently based upon insufficient evidence. We find it everywhere throughout the season, on leaves in wet, shaded, places, and sometimes in large fruitings. The color varies from occasional brick red, to more often ochraceous, and again almost white. In many of the best developments of separated sporangia, the hypothallus is hardly evident. In other specimens the sporangia are heaped and superimposed, in clusters, on a reddish hypothallus, and with large, hollow, columellae.

Var. *echinulatum* Meylan has been collected at Meadow Brook. The sporangia are well rounded, of a bright yellow color, and the spores are marked with strong, dark spines, which are much more pronounced than those on the spores of the typical form. The spores are identical with those on a slide of spores, courteously sent to me by Dr. Meylan.

7. *DIDERMA SPUMARIOIDES* Fries. It seems that we do not have this species in the large colonies of crowded sporangia as it is

usually found. Our collections are small, in separated sporangia, more as in *D. effusum*. The small, pale, columella is there; the layers of the sporangial wall are combined; and the spores are larger and darker, characters separating the species.

8. *DIDERMA TESTACEUM* (Schr.) Pers. The pinkish, circular sporangia are to be sought for on leaves in marshy places. The color fades to white. It is common on Long Island, in small colonies, from June to October.

#### 15. *DIDYMIUM* Schrad.

Separated from *Diderma* because of the crystalline nature of the lime in the sporangial wall. Usually this is in stellate crystals and well marked, but occasionally the lime may be as angular or irregular granules.

1. *DIDYMIUM ANELLUS* Morgan. The species, as represented on Long Island, seems to be extremely variable in capillitial and spore characters. We have a dozen or more collections from various places, no two of which are alike, but all of which are similar in their general appearance to one from Mineola, which consists mainly of small, centrally depressed sporangia, with circumscissile dehiscence, and short plasmodiocarps. The shape ranges, in other gatherings, to slender, elongated, or branching and netted plasmodiocarps, with few or no sporangia. The scanty lime deposits may be of small or large crystals; the capillitium of stout, flexuose threads, or slender threads, forking, branching or anastomosing; the spores vary in color from grayish-violet to darker, purplish-brown, faintly or strongly spinulose, and in size from 8.5–12  $\mu$ . Miss Lister suggested the probable species after examination of some of the earlier, obscure collections, and her judgment was confirmed by the later one from Mineola, which is typical. Two fruitings from Jones Beach, referred to in my paper on the Mycetozoa from Jones Beach State Park (*Mycologia* 22: 259, 1930), and tentatively regarded as sessile forms of *Didymium melanospermum* (Pers.) Macbr., belong here. On leaves, twigs, and ground debris, throughout the season from July.

2. *DIDYMIUM CLAVUS* (Alb. & Schw.) Rab. By careful search, the species may be found on dry, dead, grasses, sedges, and stalks, at many places on Jones Beach. It has also been collected at

several other localities. It differs from similar forms by its shape, and the absence of a columella, which is replaced by the black, thickened base of the sporangial wall. July to September inclusive.

3. *DIDYMIUM DIFFORME* (Pers.) Duby. An inconspicuous form found frequently on Long Island, and probably common elsewhere, but overlooked as an uncertain slime mold. The small, white, flattened sporangia and plasmodiocarps, with smooth, egg-shell like walls, resemble some phases of *Diderma effusum*, and may be mistaken therefore in the field. The fructifications are small, but usually numerous and scattered over a wide area on dead leaves, herbaceous stalks and stems, and other ground matter. Heaps of decaying hay, straw, and manure are also good habitats. Throughout the season.

4. *DIDYMIUM EXIMIUM* Peck. We have only one collection which has the pale, rough, discoidal columella. A gathering made in the Adirondack Mountains, with depressed, yellowish sporangia, agrees with the description of Macbride and Martin, and is so different from *D. nigripes* and *D. xanthopus*, that if considered as typical, it strengthens my opinion, that *D. eximium* should be regarded as a distinct species.

5. *DIDYMIUM MINUS* Morgan. The form is not rare, and may be found frequently among collections from wet areas, of the species of *Didymium* and *Diderma* that have similar habitats. It is sometimes regarded as a variety of *Didymium melanospermum* (Pers.) Macbr. from which it differs mainly in sporangial and spore size. The Long Island forms are constant in the small sized sporangia, about 0.5 mm., and the small spores, about 8  $\mu$  diam. We have not found *D. melanospermum* here, or any forms that are intermediate between the two species. Many collections of both, made in the Adirondacks by myself and associate, show the same distinct differences. Occurs on leaves, etc., and collected on Long Island during June and July, but probably fruits throughout the season.

6. *DIDYMIUM NIGRIPES* (Link) Fries. We have a few, small, gatherings of this species. The sporangia have dark, almost black, translucent, stalks, and the columellae are small, dark, and globose. In one of our collections the latter are elevated so that they are



in the center of the sporangia, a feature not uncommon in *D. xanthopus*. When the stalks are short, *D. nigripes* may be confused with long stalked forms of *D. minus*, but the stalks there are opaque. Rarely found, June and July.

7. *DIDYMIUM OCHROIDEUM* G. Lister. Found at Albertson in June and July 1926, July 1928, and August 1933, and also at Merrick in July 1926. The first collection is mentioned by Miss Lister in the original description of the species (Jour. Bot. 69: 297. 1931). The fruitings are very small, less than 1 sq. cm., and are on leaves, stalks, etc. The slender plasmodiocarps and depressed sporangia are yellow or ochraceous in color, and thickly coated with large, stellate, crystals of lime. All the earlier collections have spores that are practically alike, pale, violet-gray, almost smooth, 6-7  $\mu$  diam. The last, made in August 1933, has larger, darker spores with a brownish tinge. They are distinctly warted and the size is about 8  $\mu$ . The species appears to be related to *D. anellus*, and resembles phases of the latter as found on Long Island, except in the color, and the paler, smaller, and smoother spores. An apparently intermediate form from Albertson has white sporangia and plasmodiocarps, that show in parts a slightly yellow tinge, and have an orange colored floor. The spores measure 9-9.5  $\mu$ , slightly darker and rougher than the 1933 specimens of *D. ochroideum*. I regard this form as nearer to *D. anellus*, but showing a relationship to *D. ochroideum* in the yellow tints.

8. *DIDYMIUM SQUAMULOSUM* (Alb. & Schw.) Fries. One of the most variable, and at the same time, one of the most abundant of the Mycetozoa. We find it everywhere, in all of its numerous phases, on leaves and other ground matter, throughout the season. The white, circular hypothallus is absent in many of our collections of sporangia. Stalked and sessile sporangia, with a wrinkled crust of lime crystals, are frequent. From Jones Beach we have elongated plasmodiocarps, several millimeters in length, with stalks at each end that continue through and join as columellae. We also have diffused, netted plasmodiocarps, which closely resemble certain phases of *Didymium anellus*, and can only be distinguished by the presence of an occasional sporangium. The species offers some difficulties to the student because of the numerous variations,

but the recognition becomes easier after a little acquaintance with them.

9. *DIDYMIUM XANTHOPUS* (Ditmar) Fries. This is our most abundant species, and so constant that it may be recognized with a hand lens, or, when better known, with the unassisted eye. It fruits everywhere on leaves, in wet, shaded places, and at appropriate times, after a few days of dry weather, may be observed in thousands of sporangia. Not uncommon are colonies with sporangia free from lime, which are probably *Didymium affine* Raunk., although the latter is regarded as synonymous with *D. squamulosum*. The plasmodium is colorless.

*D. xanthopus*, together with *D. eximium* are regarded in other quarters as varieties of *D. nigripes*, although when typical, the three forms are distinct in important characters that can be readily recognized. *D. xanthopus* has globose sporangia, an orange or reddish stalk, and a pale yellow or white, globose or turbinate, columella; *D. nigripes* has globose sporangia, a dark almost black stalk, and a small, dark, globose columella; *D. eximium* has somewhat depressed sporangia with a yellowish color, an orange to reddish stalk, and a rather large, pale, discoidal columella, that is more or less rough. While intermediate forms do occur frequently, I have not found variation among the sporangia of the same fruiting. It seems to be better to regard the three forms as separate centers with specific rank, which is done so often with others that are much closer to neighbors than these are.

## 16. *ENERTHENEMA* Bowman

The sporangia of the genus are like those of *Comatricha* in form, color, and stalk, but the stalk continues through to the top, and expanded there, appears as a shining disc on the outside top.

1. *ENERTHENEMA BERKELEYANUM* Rost. Since the first collection from Long Island in 1926 (*Mycologia* 19: 315-316. 1927), Mr. Rispaud has found it on timbers, at the Army Base pier in Brooklyn, in June 1931, and at Mitchell Field in September 1933 and June 1934. All the collections are similar in the varying size of the sporangia, and the color also varies from purplish-brown to almost black, sometimes in the same colony. The spores

throughout are clustered, strongly spinulose on the exposed surface, purplish-brown in color, and measure 12–13  $\mu$ . Otherwise the form is like *E. papillatum*.

This form with clustered spores is rare, as it has been reported on two occasions only, aside from the Long Island collections. Its entry into Long Island is indicated somewhat by its collection in Brooklyn, and subsequent occurrences at Mitchell Field. The Brooklyn locality is the U. S. Army Base pier on New York Harbor where transports carrying troops and army supplies are docked. Mitchell Field is the U. S. Army Aviation Field near Mineola. I do not believe that the form is indigenous, but that the spores have come here from elsewhere by modern means of transportation, and, finding suitable conditions, have germinated and developed. Perhaps, in some other part of the world, the form is common, but lacking students, has not been observed.

2. *ENERTHENEMA PAPILLATUM* (Pers.) Rost. A fairly abundant species although much of the material is in poor condition, as the sporangia are fragile, and the spores and capillitiums are soon dissipated. It fruits on wood, throughout the season, but is more abundant in late May and June. The species has free spores, and all collections should be examined closely, in order to make certain that they are not the rare *E. Berkeleyanum*, which is similar, but has clustered spores.

## 17. ENTERIDIUM Ehrenb.

1. *ENTERIDIUM OLIVACEUM* Ehrenb. Not rare in recent years, as it has been found three times with forest surroundings, three times on timber stored on the Army Base pier in Brooklyn, and three times on the old wood piles at Mitchell Field. The species is more abundant in Europe than it is in North America, and here again it is suggested, that its migration into Long Island may be traced to its arrival, since the late war, in transports carrying troops and war material. The form has many aethalia to the fructification, and a thin, silvery, fibrous-like hypothallus is often present. The spores in all collections are olive-green in mass, and yellow by transmitted light. In all but one gathering, they are in large clusters, marked on the exposed surface with strong, pointed, spines, and measure 9.5–12  $\mu$ . A large collection from Albertson

has free spores,  $11\ \mu$  in size, and minutely spinulose over the entire surface. This is *Enteridium simulans* Rost., and may well be regarded as a distinct species, but I am informed that forms with free spores are frequently found in Europe, and that no particular importance is attached thereto. On wood, June to November.

2. *ENTERIDIUM ROZEANUM* Wingate. At times it is difficult to distinguish this species from *Reticularia Lycoperdon* Bull. If the aethalium is small, of a chestnut-brown color, and seated on a white, spreading hypothallus, it is probably *E. Rozeanum*; but if doubtful, there is only one way to make certain, and that is by cutting into the aethalium, blowing out the spores, and examining the pseudo-capillitium, as the spores of the two species are similar and nothing can be learned from them. This analysis usually ruins the specimen. The larger aethalia approach the silvery color of *R. Lycoperdon*, but generally, are more irregular in shape, or consist of confluent, smaller aethalia. They are also often infested by the larvae of insects. The form is common, usually in single aethalia, but occasionally with more. We have one development of twenty-four. On wood, in the late season after August.

## 18. *FULIGO* Haller

The genus is represented on Long Island by two species, one of which is abundant and the other not rare. The fructification is aethalioid, and the colors conspicuous enough to be easily seen in connection with the large size.

1. *FULIGO CINEREA* (Schw.) Morgan. Not at all rare if looked for on the proper habitat. We have found it, in large developments, on almost every pile of hay, straw, and manure, in shaded places, that we have examined during the first or second year of decay, and also occasionally in the forest on leaves and twigs. The forest fruitings are small, and should not be confused with *Fuligo septica* var. *candida* which is far more common there. The large, dark, rough, spores, ellipsoid in all of our material, are determinative. Var. *ecorticata* Lister is associated, more or less, with the typical form when on debris piles, and seems to be only a phase developed under changing meteorological conditions. Found from July to October.

2. *FULIGO SEPTICA* (L.) Weber. The species, abundant throughout the season, occurs in almost every variety and phase that has been described or mentioned. The color ranges from pure white, through all shades of yellow and red, to deep brown. In almost all of our material it is only the outer line that is colored, the lime in the capillitium being white. The capillitium may be densely calcareous, or again, more physaroid with small, fusiform, lime knots. We have several small aethalia about 5 mm. in size, that have thin, iridescent, membranous walls, scantily beset with crystalline lime granules, and an abundant capillitium without lime.

There is no end to the number of varieties that may be proposed in the species. I follow the division of Lister, based on color regardless of the shape of the aethalia or the nature of the cortex. Yellow forms of all shades, from lemon to deep orange, are considered typical. Var. *candida* (Pers.) R. E. Fries is the white form, quite common here in individual, small, aethalia, and at times in larger, pulvinate masses. The latter resemble *Fuligo cinerea*, from which it can be distinguished by the smaller, globose, almost smooth, spores. Occasionally, in the latter phase, the outside lime is in crystalline granules, densely sprinkled. The red forms, ranging to dark, chocolate brown, are all regarded as var. *rufa* (Pers.) R. E. Fries, and are not rare, but always in single aethalia and smaller than the typical, yellow form.

From our observations it is indicated that the plasmodia of the typical phase inhabit the ground or substratum. Fructification is often on wood or living trees, far up from the ground, but in such instances it is evident that the plasmodium has travelled in the search for food, and failing therein, was obliged to go into fruit. Developments on ground material are generally larger, more effused or broken up, and with impure or mottled colors; on wood, they are more compact, rounded, and with cleaner, brighter colors. Var. *candida* has plasmodia thriving in decaying wood. The less common var. *rufa* has not been studied so closely. The plasmodial color of the species is yellow or white.

## 19. HEMITRICHIA Rost.

Related to *Trichia* and *Arcyria*. From the former it is separated by the netted character of the capillitium; from the latter, by

the spiral bands thereon. The color of the sporangia is some shade of yellow except in *H. vesparium*, where it is red.

1. *HEMITRICHIA CLAVATA* (Pers.) Rost. Easily recognized, and common on wood in all months of the season, but rarely in fruitings more than 8 to 10 cm. across. It varies much in general appearance, size of sporangia, and other characters. One of our gatherings from Deer Park has a well developed red hypothallus indicating a red plasmodium. The plasmodium is white, usually.

2. *HEMITRICHIA INTORTA* Lister. Some years ago, we found in the Deer Park forest, in January, a development agreeing with the description of *Hemiarcyria longifila* Rex, which Lister makes synonymous with *Hemitrichia intorta*. Later in February, and again in November of the same year, similar developments were found. They all have a very elastic capillitium that may be drawn out to a length of 10 to 15 mm., and thick, short, stalks, filled with spore-like cells at the top, but not so evident at the base. The late Prof. Macbride, and other students to whom the form was sent, regarded it as *H. intorta*, but it appears to me now after further study, as a cold weather phase of *Hemitrichia clavata*, which latter is sensitive to such conditions. Rex in the description of *H. longifila*, emphasizes the elastic capillitium and the similarity to *H. clavata*, and the question arises that Rex's form may also be an abnormal phase of *H. clavata*, and that interpretations of *H. intorta* based upon *H. longifila* may be uncertain. *H. intorta* has been rarely reported from North America. Our specimens are doubtfully placed here.

3. *HEMITRICHIA SERPULA* (Scop.) Rost. A beautiful species when perfectly developed and mature. The yellow, branched plasmodiocarps are common, on wood throughout the season. The plasmodium is yellow.

4. *HEMITRICHIA STIPITATA* (Masse) Macbr. I report this form because it may be a distinct species, but I have doubts. It occurs on Long Island, quite typical, including sporangia on confluent stalks as mentioned by Masse. It seems to be a wide departure, in certain directions, from the variable *Hemitrichia clavata*, which has other phases equally as far away. Our forms have long, thin, stalks, weak at the top so that the sporangia nod, the

stalks at times confluent in doubles, either joined at the bases, or, almost to the tops and without vestiges of the merging. The cup is shallow, the peridium turned down over it and breaking away in small circular plates. The capillitium is smooth, with no free ends, and the mass rounded, and paler in color than typical *H. clavata*. One or more of these features are frequently observed in other phases of *H. clavata*, and their combination here, with nothing very distinctive, seems to be insufficient to regard the two as specifically distinct. It merges gradually into *H. clavata*, so that there is no way of determining where one commences and the other ends, and only in rare instances is it possible to completely reconcile specimens with Massee's description. Four collections on wood.

5. *HEMITRICHIA VESPARIUM* (Batsch) Macbr. Easily recognized in the field by the red color and clustered sporangia, which resemble a miniature wasp's nest when the cups are empty. We have beautiful examples from Great Neck, with circumscissile dehiscence by a perfect lid. Common, on wood throughout the season.

## 20. LACHNOBOLUS Fries

A monotypic genus. Two other species included by Machride and Martin are clearly *Arcyria*, resembling *Lachnobolus* only in the occasional, flaccid capillitium, a feature frequently noticed in other species of *Arcyria*. One of these species is reported in this paper as *Arcyria occidentalis* (Macbr.) Lister.

1. *LACHNOBOLUS CONGESTUS* (Somm.) Lister. Said to be rare in North America, but we have four collections from three different places, one of which was my back yard where it developed on old sugar bags used in covering plants. The fruitings are very small, and may be mistaken, when old, for faded forms of the more common *Trichia persimilis* or *Oligonema nitens*. The spores and capillitium, of course, are diagnostic. September to November.

## 21. LAMPRODERMA Rost.

The sporangia of the genus are beautiful with their metallic tints of blue, silver, and brass. Species cannot be distinguished in the field very well, so that it is better to analyse each collection as to

capillitium, columella, and spores. There is considerable variation in the same species from different territory, but our Long Island forms are typical and constant, so that they may be determined without difficulty, by the characters mentioned.

1. *LAMPRODERMA ARCYRIONEMA* Rost. Common on wood throughout the season. The species is recognized by the columella which penetrates the sporangium about half-way, and then divides into several branches forming the primary branches of the netted and anastomosing capillitium.

2. *LAMPRODERMA COLUMBINUM* (Pers.) Rost. The columella in all of our material is long and tapering, with the capillitium radiating from all parts of it. The collections are from the swamps on mossy stumps, from about the middle of September and through October. Our best field is along Meadow Brook, east of the Village of Roosevelt, where it fruits annually in abundance.

3. *LAMPRODERMA SCINTILLANS* (Berk. & Br.) Morgan. A very small form that is difficult to find and fruiting on leaves, stems, grass, etc., during the summer months. We have it from several places where careful search has been made, and it is probably common enough but escapes detection. Sporangia from Jones Beach are only 0.15 mm. diam. In this species, as well as in *Lamproderma violaceum*, the capillitium springs from the top of the columella only. The capillitium here is brown or dark to the tips and somewhat pale at the base where it leaves the columella. The spines on the spores are stronger and more separated than in *L. violaceum*.

4. *LAMPRODERMA VIOLACEUM* (Fries) Rost. The capillitium is pale, or when darker, the extremities are pale, so that if the sporangia are blown out they present a hoary appearance. The spores are larger than in *L. scintillans* and more closely spinulose. We have but a single collection, which is odd, as the species is fairly common elsewhere.

## 22. LEOCARPUS Link

A monotypic genus.

1. *LEOCARPUS FRAGILIS* (Dickson) Rost. A handsome form to be found on leaves, twigs, etc. It is common and observed several times during a season.



## 23. LICEA Schrad.

1. LICEA BIFORIS Morgan. An extremely small form and rarely reported because of its habitat beneath the bark of dead trees. It may be necessary to strip many trees and go over them with a lens in order to find the yellow, almond-shaped sporangia, although the frequent association of the species with the much larger *Perichaena corticalis* is of aid in searching for them. We have five collections, from July to October.

## 24. LINDBLADIA Fries

A monotypic genus close to *Cribraria*, but with the sporangia confluent to form aethalia.

1. LINDBLADIA EFFUSA (Ehrenb.) Rost. Not well distributed over the area. We have found single aethalia on two occasions at Albertson, and, at Jones Beach, numerous developments were taken, over two seasons, from old textile rubbish. The latter were in company of *Cribraria argillacea*, but without intermediate forms. It is difficult sometimes to separate specimens from certain phases of *Tubifera ferruginosa*. The walls of the confluent sporangia are studded with the so-called plasmodic granules which are not present in *Tubifera*. June to September, on wood.

## 25. LYCOGALA Adanson

1. LYCOGALA EPIDENDRUM (L.) Fries. Appears in the spring in small, feeble, fruitings, from the sclerotium revived by the warmth and rains. In later developments, from August to the end of the season, the aethalia are larger and more robust, and the distribution is wider. An interesting fruiting of a thousand or more aethalia, on the sand of Jones Beach, came from plasmodium in a large quantity of old, wood-pulp newspapers buried in the sand. Common on wood.

2. LYCOGALA EXIGUUM Morgan. This may be a variety of *L. epidendrum*, but it is always smaller, and darker in color; and is never in the company of the latter. It occurs only in certain places, and in the Albertson kettle hole, where *L. epidendrum* is frequent, it has never been seen. On wood, from July, and not rare.

3. *LYCOGALA FLAVOFUSCUM* (Ehrenb.) Rost. Has been collected a number of times, on wood, at widely separated stations, and as often as four times in one season. The aethalia are so large and conspicuous that they cannot be missed, yet they were seen only in the years 1924, 1928, and 1933 and not intervening. The occasional appearance has been noted by others.

## 26. *MUCILAGO* Adanson

The genus, with its crystalline lime, is similar to *Didymium*, but the sporangia are confluent and form effused or pulvinate aethalia. There is only one species.

1. *MUCILAGO SPONGIOSA* (Leyss.) Morgan. Has been found only at Albertson, on a pile of manure, where it appeared three times successively, from July to September in 1933, and not since. It is peculiar, that the first fruitings have spores 2–3  $\mu$  smaller than those of the later one, which are 12  $\mu$ . All the spores are very dark, almost opaque in water, and strongly spinulose.

Several solid, compact, aethalia of var. *solida* Sturgis were collected on cottonwood at Mitchell Field, the largest about 3 cm. across. They appear much like *Fuligo septica* var. *candida*, and have closely interwoven sporangia covered by a thick crust of lime, not at all like the loosely clustered, irregular sporangia of the typical form. There is not much difference in the spores or capillitium. The black spore mass distinguishes the form from *F. septica* in the field, and the crystalline lime, with spore characters, are diagnostic.

## 27. *OLIGONEMA* Rost.

A genus closely related to *Trichia*, with the sporangia heaped or clustered, and with faint or obscure spirals on the elaters of the capillitium.

The words dextrose and sinistrorse are confusing, as applied by authors in contradictory ways to the windings of the spirals in this genus and the genera *Trichia* and *Hemitrichia*. In *Oligonema flavidum*, the spirals wind in a contrary direction to those in species of *Trichia*. Likewise in *Hemitrichia leiocarpa*, but the figures of the latter in both the Lister and the Macbride and Martin monographs depict them in the same way as in *Trichia*. A simpler way

of explaining the direction of the windings is to consider them as similar to those of a screw-thread. An ordinary screw has what is called a right-handed thread. A thread winding in the other direction is called a left-handed thread. In all species of *Trichia*, *Hemitrichia* and *Oligonema*, reported in this paper, except *Oligonema flavidum*, the spirals wind like a left-handed thread. In the species excepted, they wind like a right-handed thread or ordinary screw. The direction of right and left is not affected by the usual reversal of the image in the microscope.

1. *OLIGONEMA FLAVIDUM* Peck. Common, on wood throughout the season. The sporangia are larger than those of *O. nitens* and ovoid in shape, the longer axis two or three times that of the shorter one. The habit is more scattered, or as a single layer of compressed sporangia, not heaped or superimposed. The spores are more regularly reticulate, and the elaters of the capillitium are rougher. All of our material shows obscure spirals, the direction of which cannot be clearly determined, except in one instance. Lister says that the spirals wind dextral, which is synonymous with dextrorse; Macbride and Martin say sinistrorse, the opposite of dextrorse; but both words are intended to indicate the same course of direction. The use of the words depends upon the point from which the spirals are viewed. They have been variously applied by botanists, zoologists, and authors, and even in dictionaries, the definitions are not uniform. Forms with very small elaters are frequently observed in this species, as well as in *O. nitens*. They are not regarded as of particular significance, although described by Peck as *Oligonema brevifilum*.

2. *OLIGONEMA NITENS* (Lib.) Rost. Common on wood, throughout the season. None of our material shows any traces of spirals. The capillitium is smoother, and the spores more irregularly reticulate than in *O. flavidum*, but the forms merge somewhat in their inner characters. The smaller, globose or sub-globose sporangia, and the heaped or superimposed habit, are usually sufficient to distinguish it from allied species.

The spirals on the elaters, when evident, wind as a left-handed screw. Macbride and Martin say dextrorse in the description, and sinistrorse in the paragraph following. The first is proper from their view-point of the application of the words.

## 28. PERICHAENA Fries

Four species of the genus are abundant and well distributed over the area covered. More than sixty perfectly matured collections show many intermediate forms between them, and the relations of the species to one another are so clearly indicated by a study of the collections, that I can see no reasons for separating *Perichaena chrysosperma* and *Perichaena vermicularis*, and placing them under another generic name. There are no differences of importance between the present genus and *Ophiotheca*.

1. PERICHAENA CHRYSOSPERMA (Currey) Lister. The species forms curved, ring-shaped, or elongated plasmodiocarps, with now and then sessile, globose sporangia, and may be distinguished from other species of the genus by the long spines on the capillitium. The fruitings, on bark, are very small, and almost concolorous with the habitat. Macbride and Martin regard the species as confined to forms with short spines on the capillitium, spores 7–9  $\mu$ , and lighter colored plasmodiocarps, and place it in the genus *Ophiotheca* Currey. Forms with long spines, larger spores, and chestnut-brown or black plasmodiocarps are regarded as *Ophiotheca Wrightii* Berk. & Curt. We have one collection of chestnut-brown color, with spines 1  $\mu$  or less in length, and spores 7–8  $\mu$ . Several others, varying in color from yellowish to brown, have spines up to 3  $\mu$ , and spores 8–9  $\mu$ . The most of our material has long spines, from 3–6  $\mu$ , spores 9–10  $\mu$ , and the color is either yellowish-brown or chestnut-brown, sometimes varying in the same fruiting, and perhaps due to drying in the later stage of maturity. The spines vary considerably in length, sometimes on the same capillitium, and as the other characters seem to be inconstant, it seems to me better to regard all these forms as phases of *P. chrysosperma*. One of our collections has no spines whatever on the capillitium, and the spores are 9.5–10  $\mu$ . It consists of yellowish-brown sporangia and a few curved or ring-shaped plasmodiocarps, with irregular lines of dehiscence, sharply defined, as in some phases of *P. corticalis*. It is placed with the present species but apparently approaches the latter. Common and often collected in the later months of the season, after August.

2. *PERICHAENA CORTICALIS* (Batsch) Rost. Typical forms as found here are sessile, subglobose, not crowded or polyonal, dehiscing along broad lines of areolation, or in a circumscissile manner with a distinct lid. The capillitium is scanty, and the spores  $12\ \mu$  or more in diameter. Collections with sporangia rounded on top, but polygonal in shape by pressure, and crowded together or arranged in irregular chains, have a more profuse capillitium and spores about  $10\ \mu$ . They are common, and regarded as phases of the present species, as usually no typical forms of *Perichaena depressa* are with them. However, one collection has large, typical sporangia of the latter present, and indicates that the other forms may be intermediate between the two species. All phases are common in the later months of the season from September on. Usually beneath the bark of decaying, fallen trees.

3. *PERICHAENA DEPRESSA* Libert. Typical examples are distinguished from *P. corticalis* by the larger, polygonal, depressed or flattened and crowded sporangia, with smaller spores, about  $10\ \mu$ , and a more profuse capillitium; but there are many collections of intermediate forms. We have large, hemispherical sporangia with small spores. Others, similarly shaped but smaller, have spores about  $11\ \mu$ , and approach *P. corticalis*. The main distinctive character between the two species is the shape of the sporangia, as assumed in fructification. Spore and capillitial characters, as well as manner of dehiscence, differ so much in the intermediate forms, that it is impossible to say with certainty where they belong unless typically shaped forms are present. *P. depressa* is common, in color variations from reddish-brown to black, and the lid is occasionally sprinkled with lime. On wood, usually beneath the bark, throughout the season from July.

4. *PERICHAENA VERMICULARIS* (Schw.) Rost. Common and occurs usually on dry stalks of dead plants, thistle, sumach, etc., also on leaves, twigs, and the outside bark of dead trees. The species forms slender, elongated, or netted, plasmodiocarps, with occasional rings or sporangia. The color is ochraceous or umber, lighter than in *P. chrysosperma*, from which it is distinguished also by the larger spores and the different capillitium. Throughout the season.

## 29. PHYSARELLA Peck

A monotypic genus.

1. *PHYSARELLA OBLONGA* (Berk. & Curt.) Morgan. A beautiful form and not rare. Our best developments are from a decaying log, in a dense thicket, in the Great Neck swamp, where it appeared twice each season for a number of years, as sporangia and plasmodiocarps. On these occasions it was associated with *Physarum polyccephalum* Schw., and at another time with *Physarum gyrosum* Rost. There may be some close relation between the three species as usually we have found two of them together on the same host. July to September.

## 30. PHYSARUM Pers.

This, the largest genus of the Mycetozoa, is not as well represented on Long Island as other genera are proportionately to the number of species. Forms found inland, not far away, are rarely seen here or not at all. We have noticed that certain species are confined to a few small areas and fruit there repeatedly. We hope to uncover new hiding places and discover forms that we feel are here, but, small and on leaves, are rarely seen.

The genus is allied to *Badhamia*, differing in the character of the capillitium. The key to the species of the genus in the Lister Monograph is of inestimable help in making determinations, and the student is advised to master it thoroughly. In typical cases, and keys are based on such, the species may be worked out, almost invariably.

1. *PHYSARUM BOGORIENSE* Racib. A small gathering on decaying grasses, at Jones Beach in September, is quite typical, and was verified by Miss Lister.

2. *PHYSARUM CINEREUM* (Batsch) Pers. Abundant throughout the season on leaves, twigs, etc. There is much variation in the amount of lime in the capillitium, and in the spore size, the latter from 7–11  $\mu$ . Certain collections, with large sporangia 1 mm. across, or with large spores and abundant lime, were formerly regarded as *Physarum vernum* Somm., a species allied to *P. cinereum*. A careful study of an extensive amount of material collected here convinces me that *P. vernum* is not among it, and

that all the collections are phases of *P. cinereum*. *P. vernum*, as shown by Swiss specimens, is large, with much lime, and darker, larger, rougher, spores. One or more of these characters are always missing in our doubtful material.

3. *PHYSARUM CITRINUM* Schum. Rare, as it has been found only twice. The sporangia are more robust than in *Physarum tenerum*, and are on stouter stalks. The yellow lime-knots are larger and irregular in shape, not rounded. In one of our collections, the columella is obsolete. July and August.

4. *PHYSARUM COMPRESSUM* Alb. & Schw. Colonies of laterally compressed sporangia are not rare, usually on ground rubbish, but also on wood. I include only such colonies with compressed sporangia throughout, or, which among more irregularly shaped ones, show indications of compression with splitting along the ridge. One collection, that cannot be assigned here clearly, is put with the irregular group discussed under *Physarum notabile*.

5. *PHYSARUM CONFERTUM* Macbr. The species is close to *P. cinereum*, and sometimes difficult to separate, but the combination of heaped sporangia, with larger spores, is generally sufficient to distinguish it. There are phases of *P. cinereum* with large spores, and the sporangia not heaped; other phases have somewhat clustered sporangia, but small spores. *P. confertum* is also close to *Physarum virescens*, which it resembles except for the yellow color. The species is common on Long Island, more often in July and August. It fruits on leaves, frequently on living plants, which the white plasmodium ascends before fruiting.

6. *PHYSARUM DIDERMOIDES* (Ach.) Rost. Usually on locust wood. Common from July to October, more often in the later months. Specimens kindly determined for me by Miss Lister as var. *lividum* are both sessile and stipitate, and appear as groups in developments of the typical form. I doubt that the variety is more than a phase of this variable species.

7. *PHYSARUM FLAVICOMUM* Berk. Not rare in the months from June to September. The sporangia are always gray, steel-blue, or iridescent bronze, but not yellow. A gathering from the Army Base at Brooklyn is remarkable for the great amount of lime in the capillitium. Another from Mitchell Field, with direct lines of communication from the Army Base, has far more lime than

usual. In a second collection from Mitchell Field, the nodes of the capillitium are deep orange-colored, almost brown.

8. *PHYSARUM GALBEUM* Wingate. May be said to be common as we find it almost every season while examining leaves and twigs in the search for ground species. The fruitings, however, are very small, consisting rarely of more than a dozen or so sporangia. The dense capillitium is almost limeless, and the threads range in color from pale yellow to hyaline.

9. *PHYSARUM GLOBULIFERUM* (Bull.) Pers. The species is common on wood from July to October. The stalks may be stout or slender, varying in the amount of the included lime, and at times confluent or branching with clustered sporangia. When the capillitial line is more angular or branching, and yellowish in color, the approach is towards *Physarum murinum*. Much of otherwise typical material shows a tendency to pale yellow in the color of the lime. Other gatherings approach *Physarum notabile*, in external appearance, but are distinguished by the persistent, globose capillitium, the columella, and the smaller spores.

10. *PHYSARUM GYROSUM* Rost. The species was found at Manhasset as far back as 1923, and since then five more collections have been made, so that it is not rare. The colonies are large, extending over twigs, stems, leaves, etc., usually on rubbish piles, and once on the grass of a lawn. It is probably far more common than recorded, and as it resembles plasmodiocarpous phases of *Physarella oblonga*, may easily be mistaken therefore. The internal lime is white, not yellow like in the latter species. In most of our collections the prevailing tints are bluish, not pink. June to September.

11. *PHYSARUM LATERITIUM* (Berk. & Rav.) Morgan. The normal form, with scarlet lime in the walls of the sporangia and short plasmodiocarps, is frequently collected and therefore not rare. It is remarkably constant, varying only in the number of the calcareous nodes of the capillitium, sometimes numerous, again few, but always rounded and with the reddish centers.

We have another phase, that was found in July of one season at Albertson, in numerous fruitings on leaves, and this is placed here tentatively. It has the same habit as the other, but the color is yellowish-brown, due to the presence of yellow lime gran-



ules in the brown wall. The lime-knots in the capillitium are large, angular, and branching, not rounded. The spores are violet-brown, 9–10  $\mu$  diam., and distinctly warted; larger, darker, and rougher than in the scarlet form. It may be intermediate with *Physarum virescens*, or, if the production of hybrids is established, may be a hybrid between the two species. I have a firm conviction that hybrids occur, as this is the only way in which to explain the occasional occurrence of certain forms at long intervals. July to September.

12. *PHYSARUM MELLEUM* (Berk. & Br.) Massee. Common and collected almost every season on leaves, twigs, etc. July to September.

13. *PHYSARUM MURINUM* Lister. Closely allied to *P. globuliferum*, but differing in the color of the lime in the wall and capillitium. In typical examples, this is brown, but shades to pale yellow, when, the separation of the two species is difficult, and mainly a matter of personal opinion as to where the line should be drawn. The color of the lime is constant throughout the same colony, and we have found generally that the darker colored forms are in small colonies. We have many collections of the typical and intermediate forms. June to September, on wood.

14. *PHYSARUM NOTABILE* Machr. Following a strict interpretation of the rules of nomenclature, the foregoing name, as proposed by Macbride, should displace *Physarum connatum* (Peck) Lister, as the latter is in use already as a synonym, twice over. Also, the Lister description of *P. connatum* is more restricted, which was apparently recognized by Macbride in broadening the description of *P. notabile* to include *P. connatum* and some other American forms that belong here, but cannot be satisfactorily placed under the Lister description.

Closely allied is *Physarum leucophaeum* Fries, which Macbride considers as a distinct species, and Lister regards as a variety of *Physarum nutans* Pers., with somewhat differing interpretations. The entire group, with some others, overlap and vary so much that they have always been a puzzle to students and will likely continue to be, as there are no sharp lines of demarkation, except in certain cases.

Lister regards *P. connatum* as a strictly stipitate form, with a stalk free from lime or with lime in the wall only, the tube enclosing refuse matter. The spores are described as purple-brown, spinulose, and  $10-11\ \mu$  diam. We have two collections, from the Deer Park forest, that agree perfectly with this description, and are disposed of quickly. Another collection from the Wheatley Hills, has sessile, globose sporangia, in all respects superficially like others discussed here. The capillitial lime is similar, but the spores are not as dark as those in the Deer Park specimens and measure  $12-14\ \mu$ . While an October fruiting, it is perfectly mature and regarded as a phase of the present species with larger spores, there being no stalks, or compressed sporangia, to indicate that it is *Physarum compressum*.

The greatest variation occurs among a dozen or more collections from the Mill Neck swamp, half of which were successive fruitings on the same log in one season, with every reason to consider them as reappearances of the same species. The sporangia of these collections are stalked or sessile, sometimes within the same colony. All have much lime in the capillitium and resemble *P. connatum* except in the stalks and spores. None have any characters that would indicate affinity with *Physarum leucopus*, *Physarum compressum*, *Physarum globuliferum*, or any other *Physarum* of the white lime group. The stalks are solidly calcareous in some colonies, limeless or almost so with enclosed refuse matter in others, and again have lime only in the wall externally. The spores range in color from dark purple-brown, through lighter shades with a tinge of gray, to clear violet-brown, which latter prevails in most of the collections. The spores are always distinctly spinulose, and measure  $8.5-9.5\ \mu$  in the majority of cases, and in the others up to  $12\ \mu$ , with a range of only  $1-1.5\ \mu$  in the spores from the same colony. To use a process of elimination, including in *P. connatum* those forms with one or more applicable characters as given by Lister, and then placing the remaining ones with *Physarum nutans* var. *leucophaeum* or var. *robustum*, as the only places left with fittingly described characters, seems to me an absurd way of handling the situation. These forms have no relationship to *Physarum nutans* whatever. From a study of the fruitings in the field, and, having no specimens from

Long Island to show that the mentioned varieties of *P. nutans* occur here, I am convinced that all the present forms are phases of *P. connatum* or rather *P. notabile*. They are so regarded, with the suggestion that sessile sporangia, the variable stalk, and the variations in spore size and color, have not been given sufficient consideration heretofore in descriptions of this extremely variable species.

15. *PHYSARUM NUCLEATUM* Rex. Common throughout the season, in fairly large colonies of several hundred sporangia. It occurs on wood or on ground matter. The species is well differentiated, and distinguished from *Physarum globuliferum* by the non-calcareous stalk, the absence of a columella, and the central ball of lime in the capillitium. Another character, not often mentioned, is that the sporangial wall is thickened at the base, persisting as a circular plate at the top of the stalk, to which the capillitium is firmly attached. This thickening is clearly shown on the outside of the sporangia in all of our material.

A phase of *P. nucleatum*, frequently found here, has much smaller sporangia on stalks as long as in the normal form. The central ball of lime is often missing and replaced by larger lime-knots in the capillitium. The circular plate at the base of the sporangium is always present, sometimes as a fairly well defined cup. I regard this as an erratic phase, abnormally developed, under adverse conditions. It must not be confused with *Physarum pusillum*, which is entirely different.

16. *PHYSARUM NUTANS* Pers. Typical specimens are not common, as it has been found only six times in all of our collecting, and I doubt that it is so abundant elsewhere as often stated. We make many collections with white sporangia and apparent white lime-knots, but the latter when observed by transmitted light with the microscope are seen to be pale yellow in color. Such are not *P. nutans*, but are *Physarum viride* var. *incanum*. *P. nutans* should not be determined hastily on appearances with reflected light. Occurs on wood, July to September.

17. *PHYSARUM OBLATUM* Macbr. The form as we have found it at Mill Neck, on bark and regarded as typical, is practically the same as the globose form of *Physarum pusillum*, figured by Lister on pl. 43 of the Monograph, except that the capillitial lime is yel-

low, and the spore punctuation is uniform and not grouped in patches. We have a smaller form on dry, dead, stems and sedges from Jones Beach which is *Craterium Maydis* Morgan and placed by Torrend in *Physarum* as *P. Maydis*. There are no characters to distinguish the two forms, except habitat and size, and as there is hardly room for two species, Macbride's name, having priority, is recognized for both. July and September.

18. *PHYSARUM PENETRALE* Rex. We have but a single collection made at Mill Neck in June. The sporangia are yellowish in color, ellipsoid in shape, on slender, red, translucent stalks, which are curved where they enter the sporangia, and penetrate almost to the top.

19. *PHYSARUM POLYCEPHALUM* Schw. Collected at Great Neck during three seasons on the same log with *Physarella oblonga*; also at Albertson on leaves in wide spreading developments. The original color of the sporangia is yellow, which fades rapidly to gray. As noted by others, var. *obrusseum* is no more than a phase and appears throughout the collections of clustered sporangia. July to October.

20. *PHYSARUM PULCHERRIMUM* Berk. & Rav. Two collections on wood, both in August. Related to *Physarum globuliferum*, but with purplish-red color.

21. *PHYSARUM PUSILLUM* (Berk. & Curt.) Lister. The Lister interpretation of this species includes two forms figured on pl. 43 of the Monograph, which are so far apart in external appearance, lime, and spores, that when placed side by side, they appear to be different species. Perhaps they are. The typical form bears a striking resemblance to *Didymium xanthopus*, superficially, but of course is a *Physarum*. The sporangia are small, depressed globose or lenticular, with a concave or flattened base. The lime in the capillitium, while varying in different collections, is not dense. The spores in all sporangia are uniformly warted, not in patches. This form is common, and often collected on straw, leaves, twigs, etc.

We have a fine development of the other form on wood. The sporangia are twice as large as in the typical form, and are globose, not flattened or concave below. The capillitium is dense with lime, almost *Badhamia*-like, and the spores have from two to

four patches of clustered warts on the hemisphere, among the other warts. The red stalks and reddish bases of the sporangia are alike in both forms. This globose variety looks like *Physarum oblatum*, only that the lime of the latter is yellow, and when this is faded, the two are indistinguishable except for the spore differences. Throughout the season.

22. *PHYSARUM RUBIGINOSUM* Fries. This rare species has been found three times on leaves in August and September, but in very small fruitings. One of the collections has scarlet sporangia, with similarly colored, large, branching lime-knots. In another, the wall is almost limeless, and the lime in the capillitium is brown.

23. *PHYSARUM SINUOSUM* (Bull.) Weinm. This cosmopolitan species occurs on leaves, in great abundance throughout the season.

24. *PHYSARUM TENERUM* Rex. We have nine gatherings of the species, so that it is not rare. In most of them the sporangia are almost white, but the numerous, rounded, yellow, lime-knots; the long, yellow stalks, which are darker at the bases; and the missing columellae, distinguish the species. The stalks are usually sharply bent or twisted at the tops, which character separates the form from certain phases of *Physarum nucleatum*, when other characters are not well defined. On wood in small colonies, July and August.

25. *PHYSARUM VARIABILE* Rex. The typical, stalked form has not been found, but two collections of var. *sessile* Lister have been made, each on leaves in August, and at stations separated by miles. The walls of the sessile sporangia and plasmodiocarps have yellow, orange or reddish colored lime, but the capillitial lime is white or almost so. The spore size is 7-8.5  $\mu$ .

This variety has had a checkered taxonomic career. Known to students by the name here applied, a similar form was elevated to specific rank by Brandza as *Physarum sessile*. Miss Lister, in the 3rd edition of the Monograph, regards *P. variabile* as a phase of *Physarum sulphureum* Alb. & Schw., accepting *P. sessile* as a separate species, and including with the latter the sessile sporangia and plasmodiocarps formerly regarded as var. *sessile* of *P. variabile*. It should be remembered that *P. sulphureum* is generally regarded as a stipitate species, and that sessile sporangia are frequently

present in collections of typical, stipitate *P. variabile*. Now later, Brandza divides his *P. sessile*, retaining the name for forms with white lime in the walls and capillitium, and proposes the name *Physarum aurcum* for those with yellow lime. Our forms cannot be fitted with the descriptions of either of Brandza's species, by lime color or spore size, nor is it agreeable for me to stretch a point and attempt it, as I am inclined to believe that later study of further collections will indicate that all forms under discussion are phases or varieties of the same species. If that be so, *P. sulphureum* has priority, and the description of the species must be broadened. Until more light appears, I am calling our forms by the name that they have carried for years, feeling there is still enough uncertainty about uniting *P. variabile* with *P. sulphureum*, and also, that Brandza's later names may be superfluous when the confusion clears.

26. *PHYSARUM VIRESCENS* Ditmar. The species was collected several times in one season, at various stations on leaves, and once again the third following season. The typical form with heaped, yellow or greenish, sporangia, does not differ materially from heaped phases of *Physarum cinereum*, except in color. Var. *nitens* Lister was found once on leaves at Albertson. The bright yellow sporangia and short plasmodiocarps are separated, not clustered, and show a resemblance to *Physarum lateritium*, with which it appears to be intermediate. July and August.

27. *PHYSARUM VIRIDE* (Bull.) Pers. The species is abundant throughout the season, generally in the typical form or the var. *incanum*.

Var. *aurantium* (Bull.) Lister has been found twice. The color is orange, but not as dark as in specimens from other localities.

In September 1927, we found at Mitchell Field, a fruiting of typical *P. viride*, which at one end gradually merges into robust sporangia, on stout stalks, with densely calcareous peridia, and abundant yellow lime in the capillitiums. Specimens were submitted to Dr. W. C. Sturgis, who has made a study of var. *Bethelii* (Macbr.) Sturgis, and he advises me that they undoubtedly represent the variety. However, it is no more than a variety, as the gradual merging into the typical form indicates clearly that all

sporangia in the fructification have developed from the same plasmodium.

Var. *incanum* Lister is abundant and has gray or white sporangia, showing occasionally a trace of yellow, and with pale yellow lime-knots. In my opinion it is a hybrid between the typical, yellow form of *P. viride* and *Physarum nutans*. Some years ago, we found at Albertson a fructification of thousands of perfectly matured sporangia, covering an area of between two and three square feet. Only part of the fruiting was taken, and for several years, on every occasion when visiting the locality, the particular spot was examined. No further developments appeared nor anywhere in the immediate vicinity. Among the sporangia of that part of the colony removed, there are many with confluent stalks, and others that are compound. The compound sporangia are on stout stalks showing no signs of merger, and dividing about halfway up into as many as four branches, each supporting a perfectly matured sporangium. Also, among these sporangia of var. *incanum* there is a group of about a hundred sporangia, half of which are typical *P. viride*, of deep yellow color and yellow lime-knots, and the other half are typical *P. nutans*, with white sporangia and white lime-knots, the sporangia intermingled, adjacent, and alike except in color. Within this group there is another interesting feature. There are compound sporangia, as previously mentioned, which carry on different branches, white and yellow sporangia. In other words, *P. nutans* and *P. viride* have developed on the same stalk. The latter clearly indicate that all three forms in the colony have developed from the same plasmodium.

This remarkable development almost proves either of two theories. The first is, that *P. viride* and *P. nutans* are not separate species, but develop from the same plasmodium, the color depending upon unknown, varying, conditions. The other, that the colony came from a hybrid plasmodium, and that the two species are distinct. I incline to the latter view which is strengthened by the non-appearance of the form after its first collection, indicating perhaps, that the spores were sterile. Also, such occasional occurrences in other species have been observed and referred to in this paper. If the theory of hybridism should be absolutely dis-

proved, however, there is no other conclusion but that *P. viride* and *P. nutans* are phases of one and the same species.

### 31. RETICULARIA Bull.

A monotypic genus closely related to *Enteridium*.

1. RETICULARIA LYCOPERDON Bull. The aethalia, when small, are often similar in appearance to those of *Enteridium Rozceanum*, and difficult to distinguish without blowing out the spores and examining the capillitium. In this species the capillitium is free from the silvery-white cortex, and more thread-like at the top. In *E. Rozceanum*, the perforated, flattened pseudo-capillitium is attached to the brown cortex at many points. If a part of the cortex is raised and shows the perforated plates, the aethalium is that of *E. Rozceanum*. Another character of *R. Lycoperdon* is the rapid germination of the spores. In fresh, fully matured, material, this takes place in less than one hour, so that the species may be identified thereby, as in no other slime mold is the germination so rapid.

The species is found here occasionally in small single aethalia, but is not common. We have two fruitings of large aethalia, in one of which there are several aethalia up to 5-7 cm. across. The last mentioned collection has spores in large, loose clusters. The plasmodium is said to be white. In the last mentioned collection it was dark purplish before fruiting. Occurs May to October.

### 32. STEMONITIS Gleditsch

The genus presents problems in classification. Three well marked centers are seen; *S. fusca*, *S. splendens*, and *S. axifera*. Around each are grouped a number of forms, some of which are generally regarded as of specific rank, and others treated as varieties. The latter varietal forms are frequent in North America, and in most instances so different, that they can be recognized with a hand lens. While it is true that they are more or less related to one or other of the three species mentioned, it is also true that such relationships are frequent throughout the Mycetozoa, and it is mainly a matter of personal opinion whether or not to regard them as distinct species. *Stemonitis* is a difficult



genus to study, and dividing it into more species with full descriptions, instead of short varietal notes, will do much to help the student to a better understanding of the genus. As a matter of convenience, I am reporting as specific those forms found on Long Island which are regarded by the Listers as varietal, agreeing however, that their position as such is not fully established.

The genus is well represented on Long Island. The one outstanding feature is, that the spores in many species are small, frequently of less diameter than the smallest sizes mentioned in descriptions.

1. *STEMONITIS AXIFERA* (Bull.) Macbr. The species is common and occasionally in large fructifications of many clusters. The rusty color, fine meshed surface net, and small spores, serve to distinguish it. The spores in almost all of our material are less than  $5\ \mu$  diam. The plasmodium is white. Occurs throughout the season, on wood.

2. *STEMONITIS CAROLINENSIS* Macbr. Easily recognized, but apparently only a phase of *Stemonitis pallida*. The members of the group to which it belongs are so closely related and interwoven, that allowances must be made for slight differences. Our one undoubted specimen has spores that measure  $4.5\text{--}5\ \mu$ , a permissible variation. On wood, June.

3. *STEMONITIS CONFLUENS* Cooke & Ellis. The plasmodium, in fructification, breaks into numerous parts, forming as many as thirty to forty small clusters of dark, confluent, sporangia. The clusters vary from 1 to 20 mm. across. We have three collections on wood. September and October.

4. *STEMONITIS FENESTRATA* Macbr. The form may be recognized in the field with the unaided eye by one familiar with its features, because of certain peculiarities of habit and appearance at different stages of maturity. The almost complete absence of connecting threads between the columella and surface net seems to set it out as a center sharply away from *Stemonitis splendens*. The eccentricity of the columella along the net, and the loosely, spiral ascent, are of minor importance, as such features are noticeable, in a lesser degree, in other species with a lax, inner capillitium. They are due to a twisting of the entire sporangium during drying and spore dispersal, and are more emphasized after

complete desiccation. The form is often found and usually in large fruitings. On wood throughout the season.

5. *STEMONITIS FLAVOGENITA* Jahn. While critically studying a large number of collections of the small-spored phase of *Stemonitis herbatica*, mentioned under that species, a specimen was found having several small clusters of sporangia, with pale, ferruginous spores,  $9\mu$  diam. The sporangia are 5 mm. tall, and on short stalks of 0.8 mm. The columella has the membranous cap at the apex, and the capillitial threads have many broad expansions with a delicate, spinose, surface net. It is typical *S. flavogenita*. The species has probably been overlooked heretofore in the field, as it bears also a superficial resemblance to *Stemonitis Smithii*. The small species of the genus, *S. flavogenita*, *S. Smithii*, *S. herbatica*, *S. hyperopta*, *S. pallida* and *S. virginensis*, all resemble each other externally, so that careful microscopical examination is necessary in order to separate them. On leaves, July.

6. *STEMONITIS FUSCA* Roth. If the given spore diameter of  $8-10\mu$  is accepted, typical *S. fusca* is certainly very rare on Long Island. We have numerous collections of the species, as it is common and abundant, and in all but one or two of fifty or more examined, the spores ranger from  $6-7.5\mu$ , no matter what the color of the sporangia or spores may be. There is nothing in the description of var. *rufescens* Lister to distinguish it from phases of the typical form, except the smaller spore size given as  $.5-8\mu$ . Any emphasis laid upon the faintness of spore markings is of little importance as it is quite natural that smaller spores should be more faintly marked than larger ones, and as a matter of fact, it is usually the case. Small sized spores are the rule in many of the species of *Stemonitis* from Long Island, and it is evident that spore size is an inconstant factor here. I am regarding all our collections as typical *S. fusca*. There is a wider range in the spore size of *S. fusca* than heretofore believed, with no necessity for separating as varietal any forms with small spores.

The species is also unique in having spores of two distinct tints, pronounced in extreme cases when observed side by side. About half of our material has grayish-violet spores, by transmitted light. The remainder are rufous or brownish-violet. Intensity of color depends much upon the size of the spore, and this should always

be remembered in estimating spore color by transmitted light. Other conditions being equal, a small spore will be paler than a large one. A parallel may be seen in thick and thin pieces of glass, colored alike, and held against the light. The thick one may be dark or opaque; the thin one, translucent.

Several of our collections have the imperfect capillitium and surface net of var. *flaccida* Lister. The species is found throughout the season, on wood.

7. *STEMONITIS HERBATICA* Peck. The species exhibits some variation in the size of the sporangia and shape of the clusters, as well as in microscopic characters. It must be regarded as a convenient center, covering a number of forms with variable characters, which if fruiting on leaves, are well named. When the development is on wood, the approach to any other particular species is not always seen clearly. The forms we have on wood, have more or less the pallid surface net of *Stemonitis pallida*, and are regarded as closer to that species, ignoring the shape of the meshes of the surface net, which are more angular as in *S. herbatica*.

In the Albertson kettle hole, there occurs annually a small phase of *S. herbatica* about 5 or 6 mm. tall, developing on leaves in numerous, small clusters of almost erect sporangia. It has also been observed in several other places. The surface net is usually normal with angular meshes, again more irregular as in *S. pallida*, but without the pale color of the latter. The spores, invariably, are from 4.5–5  $\mu$ , and very constant in the size. There is nothing otherwise to distinguish the form from *S. herbatica*, and recalling the tendency to form small spores in many of the species of *Stemonitis* here, I do not regard it as more than an interesting phase. The normal, larger, form with larger spores, is also frequent throughout the season.

8. *STEMONITIS HYPEROPTA* Meylan. The form looks like a small *Comatricha typhoides*, in the pale, lilac-brown color, and has the habit of *Stemonitis Smithii* in the few, small, clusters of sporangia to the colony. The capillitial net is sometimes almost perfectly developed, but more often lacking in the upper half. The spores do not have the few, large, warts present on the spores of *C. typhoides*, and instead are faintly or obscurely reticulated. It

is not common, but has been collected a number of times on wood from June to September.

9. *STEMONITIS PALLIDA* Wingate. The statement in the Lister Monograph, that the spores assume a coffee bean shape when dry, should be disregarded, as such effects are seen with spores of many other species, including those allied to *S. pallida*. The separation of the species from *Stemonitis herbatica* is often perplexing, but if the fruiting is large enough, the habit of forming many small groups, consisting of from two to twenty-five erect sporangia, and the pale, almost hoary, color of the sporangia, when blown out, are characteristic. The surface net is uneven, not only in the plane of the net, but also extending away from it, so that the edge view appears irregularly sinuose. This is seen occasionally in *S. herbatica*, but the tendency there is to form a more even net with regular, polygonal meshes. The spores in our specimens are from 6.5–7.5  $\mu$ , faintly spinulose, and much like those of *S. herbatica*. We have about a dozen collections, always on wood, the majority of which are typical, the others merging into *S. herbatica*.

10. *STEMONITIS SMITHII* Macbr. There is nothing of importance to separate the form from *Stemonitis axifera*, except the smaller size of the sporangia, which are up to 6 mm. tall. Minor differences, sometimes regarded as characteristic, are not constant and found also in the larger forms. We have numerous collections, each consisting of a few, small, clusters of sporangia. In moist chamber experiments, sporangia developed from a plasmodium which was greenish yellow, when extended, and dull green, when contracted. *S. Smithii* may be only a variety of *S. axifera* as the Listers regard it.

11. *STEMONITIS SPLENDENS* Rost. Common on wood throughout the season, and often in large fructifications.

12. *STEMONITIS TRECHISPORA* Macbr. Certain developments of this species are undoubtedly close to *Stemonitis fusca* in anatomical characters, but in the features of its habitat and habit it is so different that there is no doubt in my mind about its distinctness, and that its plasmodium will not produce typical *S. fusca*. If those features are unknown or ignored, it is impossible in many instances to distinguish between the two species.

The form occurs here in great abundance, at times, and we have had as many as forty or fifty fruitings within view at one time in the wet swamps. The plasmodia are milk-white after emergence, and inhabit the ground substratum, not wood as in *S. fusca*. The plasmodia do not travel, but fruit where they emerge, and frequently close to the water's edge, resulting in many poorly developed or aberrant phases with unusual variation. Molds form rapidly in the moist situations; small beetles find the spores palatable and ravage the sporangia; and as the developments are loose, fluffy, and fragile, little is left after a day or so except dark patches on the ground. This accounts for the infrequent reporting of collection in quantity. The small beetles that are found with *S. trechispora* do not infest *S. fusca*, which would indicate a toxicological factor there.

In perfect developments, and many are so, the sporangia are free, nowhere confluent, although closely compacted in clusters up to 3 cm. across. The weak, recumbent stalks are about one-quarter the total height, which is about that of *S. fusca*, and the color of the sporangia is black. The columella is weak, often twisted, and the capillitium and wide-meshed surface net are often imperfect. The spores are dark purplish-brown, range from 8.5–12  $\mu$ , and are reticulated with raised bands, continuous or broken, or reticulated with spines. In other developments the sporangia are more or less confluent, more so at the bases, occasionally assuming a pseudo-aethaloid shape with almost even surface, and suggesting *Amaurochaete*. These forms all come from similar plasmodia developing the most irregular, variable, aberrant species, that it has been my good fortune to observe closely and frequently in the field. June to September.

13. *STEMONITIS VIRGINIENSIS* Rex. A single collection from Albertson in June is on wood. The spores are typical, coarsely reticulated with continuous, narrow, raised bands. The color of the spores is pale lilac-brown, and the size 6.5–7.5  $\mu$ .

14. *STEMONITIS WEBBERI* Rex. The form has been found on wood, on three occasions at Jones Beach only. It is undoubtedly close to *Stemonitis splendens*, but readily distinguished by the open capillitium and large meshed surface net. If development is always under unusual conditions, as here at the seashore, it is prob-

ably no more than an abnormal phase of *S. splendens*. With one fruiting, a light yellow plasmodium was noted.

*Stemonitis splendens* var. *flaccida* Lister belongs with *S. Webberi* if the latter is regarded as a species. Two collections, also from Jones Beach, are clearly degenerate phases. Martin and Macbride refer to the form under *S. splendens* var. *flaccida*, and again as *Comatricha flaccida* (Lister) Morgan.

### 33. TRICHIA Haller

All of our Long Island *Trichiae* are on wood, and found to best advantage in the autumn months when *Trichia varia* and others appear in great abundance. The differences between *Trichia* and *Hemitrichia* being principally in the character of the capillitium, there are several species in each genus that are similar to others in the opposite genus, with the exception of the capillitium. Forms are occasionally found among species of *Trichia* that have a partially netted capillitium, and then other characters, particular to the species, must be considered in order to identify them.

1. *TRICHIA AFFINIS* de Bary. The species is maintained as a center between *Trichia favoginea* and *Trichia persimilis*, differing from the former in having spores with broad, pitted bands, yet forms occur with narrow bands, and when the width of the elaters does not exceed  $6\mu$ , are regarded here as the present species. When the elaters are wider, and the sporangia are cylindrical or ovoid in shape, the approach is towards *Trichia favoginea* and they are so regarded, notwithstanding the pitted character of the bands. Little of the extensive collections from Long Island of *Trichia affinis*, *Trichia persimilis* and *Trichia pulchella* is typical as regards the spores. The three forms cannot be separated definitely otherwise than by the spores, and these vary in their sculpturing from broad, pitted bands, through narrow, pitted bands, to a broken reticulation or pitted warts. These variations are found in fruitings taken from the same wood, year after year; in the same colony; and sometimes in the same sporangium. It is logical to assume that such variations do not come from any qualities inherent in the plasmodium.

A species should bring to a common center as many forms as possible, having similar characters. To maintain several centers

on an inconstant character like the spore sculpture of these forms, when all other characters are almost identical, does not clarify the taxonomy, and leaves too many intermediate and indeterminate forms. *Trichia favoginea*, with broad elaters and narrow, continuous bands on the spores is well marked. All other forms here mentioned should be regarded as phases of *T. persimilis*, the first published name. To do otherwise is to sanction the proposal of new species on trivial grounds, which practice should be discouraged.

2. *TRICHIA ALPINA* (R. E. Fries) Meylan. This species is rare except in Alpine regions. We have a small collection that agrees fairly well with specimens received from Dr. Meylan. The wall is thick, dense with granules, and black. The sporangia and plasmodiocarps spread at the bases where attached to bark on which they were found, and have an appearance of imperfect maturity externally, although the capillitium and spores are properly matured. The same feature is noticed in the Swiss specimens. The spores in our specimen measure 12–15  $\mu$ . September.

3. *TRICHIA BOTRYTIS* (Gmel.) Pers. The two collections that we have are not typical, the capillitiums consisting mainly of very long elaters, somewhat branched and netted, although short, free, elaters are present. Miss Lister, who has examined one of them, regards other characters as indicating *T. Botrytis*. August and October.

A dozen sporangia on a dry, leaf stem are regarded as var. *flavicomma* Lister. They are small, 0.3 mm. diam., on short, stout, black stalks. The peridium is purplish-brown with yellow lines of dehiscence. The profuse capillitium has free, yellowish elaters, 2–2.5  $\mu$  wide, ending in fairly long, slender points. The elaters are not straight, but irregularly sinuose, and the spirals are faint. Spores yellowish, almost smooth, 9.5  $\mu$ .

4. *TRICHIA CONTORTA* (Ditmar) Rost. Only one collection, which is typical, with uneven, irregular spirals on the elaters. Found in May, but evidently a prior season's fruiting.

5. *TRICHIA DECIPIENS* (Pers.) Macbr. Found, not rarely, during the *Trichia* season in October and November. We have one gathering with convex lids breaking away in sharp, circular fashion, which is var. *olivacea* Meylan. Another fruiting of small,

scattered sporangia, otherwise normal, was taken from the bark of a living tree.

6. *TRICHIA FAVGINEA* (Batsch) Pers. Not common, but found occasionally during the late autumn. There is some variation in spores and capillitium among our collections. The sporangia of one have elaters with blunt, truncate ends as in *Oligonema*, although otherwise normal. In all, the thickness of the elaters is from 6-7  $\mu$ , and the spore borders are about 1.5  $\mu$ . In several gatherings the spores have broader, pitted bands, with spores among them that have narrow, non-pitted bands. These approach *Trichia affinis*, but other characters are those of *T. favoginea*. The ovoid or cylindrical sporangia distinguish the species from other allied species of *Trichia* except *T. affinis*.

7. *TRICHIA FLORIFORMIS* (Schw.) G. Lister. A beautiful form when fully matured, having some resemblance to *Hemitrichia vesparium*. Sessile sporangia also occur as in the latter species. *T. floriformis* seems to fruit here only once a year, and developments on the same log, in three successive years, have appeared almost to a day. It is one of the species that are very slow in development of the sporangia, the process requiring from seven to fourteen days until complete maturity. We have it from three other stations so that it is not rare.

8. *TRICHIA INCONSPICUA* Rost. The species differs from *Trichia contorta* in no more important feature than the more perfect symmetry of the elaters of the capillitium. It seems to be a more highly perfected phase of the latter, or rather, *T. contorta* is an imperfect phase of *T. inconspicua*. There is no difficulty in distinguishing the two, and, while it may be better to combine them as a single species, the same may be said of a number of other species, that have been accepted by students on less prominent differences in characters. Three collections on wood, September to December.

9. *TRICHIA PERSIMILIS* Karst. Specimens with typical spores are not common among our collections. In much of the material, the reticulations approach more nearly those on the spores of *Trichia affinis*, but this is inconstant, varying sometimes in the same sporangium. In moist chamber experiments, sporangia de-



veloped from a yellow plasmodium. Found throughout the season, from June, which applies also to the allied species.

10. *TRICHIA PULCHELLA* Rex. This is no more than an intermediate form between *Trichia persimilis* and *Trichia affinis*. The three, when forming globose sporangia, are practically identical except for the banding of the spores. In *T. pulchella*, the bands of the reticulations are narrow and pitted, but all sorts of variations are found, from broken reticulations to broader bands. *T. persimilis* and *T. affinis* are so close, inseparable at times, that it is needless to maintain another species between them. *T. pulchella* is frequent in the joint material of the three forms mentioned. The spirals on the elaters, in our material, wind as a left-handed screw; not right-handed as in the figure of Macbride and Martin.

11. *TRICHIA SCABRA* Rost. The species is similar to *Trichia persimilis* in the sessile, globose sporangia and crowded habit. Usually it can be distinguished in the field by the darker, orange color, and the larger size of the colonies. In both species, the capillitium is usually, but not always, studded with spines. The spores are entirely different and diagnostic. It is common, as early as June, but more abundant in October and later.

12. *TRICHIA VARIA* Pers. An extremely variable form as the name implies. We have globose, ovoid, and turbinate sporangia, on stout, black, stalks; also, sessile sporangia and plasmodiocarps, the latter up to 15 mm. long. The color ranges from ochraceous-yellow to olivaceous. The species is readily determined by the presence of only two spirals on the elaters, all other *Trichias* having three or more. The spirals wind like the threads on a left-handed screw, not right-handed, as the figure in Macbride and Martin is drawn. Abundant in October and November.

### 34. TUBIFERA Gmelin

A very interesting genus. The three species, recognized as fairly well marked centers when characters are clearly shown, are connected by many intermediate forms and gradually merge into each other. The columellae in *Tubifera Casparyi*, in the best developments, show a resemblance to those in *Stemonitis* and *Comatricha*. On the other side, pseudoaethalioid forms of *Tubifera*

*ferruginosa* are often so closely compacted, and with degenerate sporangial walls, as to hint a relation to *Enteridium* and *Lindbladia*. It is possible that with further study, a line of transition may be traced from certain species of *Stemonitis* or *Comatricha* to *Cribbraria*, through *Tubifera*, *Enteridium* and *Lindbladia*.

1. TUBIFERA CASPARYI (Rost.) Macbr. A collection from the Deer Park forest shows a fine development of the columellate structure, in many of the sporangia. In other collections, there is only a mere trace, here and there in a few sporangia, and not sufficient to regard them as distinct from *Tubifera ferruginosa*. It is hardly more than a variety of the latter, in fact in much of our better material, with well defined sporangia, there is a tendency in *T. ferruginosa* to show columellae occasionally, either *Stemonitis*-like or hollow.

2. TUBIFERA FERRUGINOSA (Batsch) Gmelin. The species shows much variation in shape, from almost free sporangia, connected at the bases only and not confluent, through many stages to aethalioid-like masses with imperfectly developed sporangial walls. In such cases the tops of the confluent sporangia are flat; in the freer sporangia, conical or convex. In collections with convex caps, which are often perforated, the hollow columellae are frequently found, but in only few of the sporangia. They arise from the base within, or diagonally from the sides, or again from the cap at the perforation and then leading downwards. They are the pouch-like protuberances mentioned by Lister, and different from the long, *Stemonitis*-like columellae, with side processes to the walls, which are characteristic of *T. Casparyi*. Forms with such protuberances should be regarded as phases of *T. ferruginosa*. Occurs on wood, from June to November, and common.

3. TUBIFERA STIPITATA (Berk. & Rav.) Macbr. Practically the same as *Tubifera ferruginosa* except that the cluster of sporangia is seated upon a stout, spongy base, somewhat like a stalk, and varying in height. In our typical collections the spores are smaller than in *T. ferruginosa*, never over  $5\mu$ , and there are no tendencies towards the columellate structure of *Tubifera Casparyi*. It is not common, our best specimens coming from the Albertson kettle hole, at the time that the allied species are fruiting.

## ADDENDA

Three additional species are reported as occurring on Long Island. These appeared, as moist chamber developments, on dead oak and cottonwood bark collected in the late season of 1935, near Mitchell Field.

*COMATRICHA FIMBRIATA* G. List. & Cran. This minute species is almost impossible to detect in the field. We have watched the moist chamber sporangia develop under the microscope, and as soon as they commence to dry, the spores are catapulted away from the delicate tuft of capillitium, which often disappears, leaving only the bare stalks. The habit is scattered—a sporangium here and there—and usually along the crevices or outer edges of the bark. The developments on oak bark are typical.

*ECHINOSTELIUM MINUTUM* de Bary. An extremely small form, with a habit like *Comatricha fimbriata*, and practically impossible to find except by careful search with the microscope. The sporangia resemble those of a common *Mucor*, but the latter have shorter stalks, and are in densely aggregated colonies. The spores in *E. minutum* are globose, not ellipsoid as in the *Mucor*. *E. minutum* also developed in a moist chamber on wood collected at Sheds, Madison Co., New York.

*KLEISTOBOLUS PUSILLUS* Lipp. This forms small but numerous sporangia, so that the colonies can be seen with a hand lens. The sporangia are subglobose, bright brown in color, with convex, shining, lids, which are depressed below the rims of the sporangia. We have collected natural fruitings of this species and *Hymenobolina parasitica* Zukal at localities near Ithaca, New York, and there is little superficial resemblance between them. The last named has also many sporangia, but larger and of a dull, dark color—almost black—which makes them difficult to differentiate from the lichens on which they developed. *H. parasitica* did not develop on Long Island wood, but *K. pusillus* appeared in several developments on oak and cottonwood bark collected at Mitchell Field. The distinctions between the two species are hardly more than specific, and they might well be placed in one genus together with *Orcadella operculata* Wing., which differs materially only in the presence of a stalk. All are closely related to *Licea*, differing by the presence of a distinct lid or operculum.

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